Spyder3 Color Camera Link

User's Manual

SC-30-02k80-00-R
SC-30-04k80-00-R

Bilinear Color Line Scan Camera

PRELIMINARY

26-Jun-09
03-032-20059-00
www.dalsa.com

About DALSA

DALSA is an international high performance semiconductor and electronics company that designs, develops, manufactures, and markets digital imaging products and solutions, in addition to providing semiconductor products and services. DALSA's core competencies are in specialized integrated circuit and electronics technology, software, and highly engineered semiconductor wafer processing. Products and services include image sensor components; electronic digital cameras; vision processors; image processing software; and semiconductor wafer foundry services for use in MEMS, high-voltage semiconductors, image sensors and mixed-signal CMOS chips. DALSA is listed on the Toronto Stock Exchange under the symbol DSA. The Company has its corporate offices in Waterloo, ON and over 1000 employees world-wide.

For further information not included in this manual, or for information on DALSA's extensive line of image sensing products, please call:

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1 Introduction

The Spyder3 Color camera uses DALSA’s state-of-the-art dual line scan technology in order to deliver high color quality, low-cost and ease of use for color imaging. This camera features 2k and 4k resolutions with a maximum line rate of 18 kHz. The zero gap in between the two sensor lines minimizes image artifact. Customer selectable output formats, RGB, RG/GB, and G, provides greater flexibility to meet many application requirements.

1.1 Camera Highlights

Features

- 2048 or 4096 pixels, 14 µm x 14 µm (2k) and 10 µm x 10 µm (4k) pixel pitch, 100% fill factor
- 80 mega pixels per second throughput
- Up to 18 kHz (2k) or 9 kHz (4k) line rates
- RGB, RG/GB, or G color output formats
- Dynamic range 60 dB
- Base Camera Link configuration (8 or 12 bit)
- RoHS and CE compliant (pending)
- Pre-calibrated light sources (e.g. white LED)

Programmability

- Serial interface (ASCII, 9600 baud, adjustable to 19200, 57600, 115200), through Camera Link™.
- Mirroring and forward/reverse control.
- Programmable gain, offset, exposure time and line rate, trigger mode, test pattern output, and camera diagnostics.
- Flat-field correction—minimizes lens vignetting, non-uniform lighting, and sensor FPN and PRNU.

Applications

The Spyder3 Color camera is ideal for:

- Cotton and textile inspection
- Food, drug and tobacco inspection
- Wood, tile, and steel inspection
- Postal sorting
- Recycling sorting
- 100 % print inspection (lottery tickets, stamps, bank notes, paychecks, etc.)
- General web inspection

Camera Models

The Spyder3 Color camera is available in these models.

Table 1: Camera Models Overview

Model	Description
SC-30-02K80-00-R	2k resolution, 2 sensor taps. Base Camera Link configuration.
SC-30-04K80-00-R	4k resolution, 2 sensor taps. Base Camera Link configuration.

Table 2: Camera Accessories

Accessory	Description
AC-UC-00002-00-R	M42 TO C-MOUNT ADAPTER RH
AC-SU-00113-00-R	TRIPOD MOUNT ROHS SPYDER3
AC-UN-00002-00-R	M42 TO F-MOUNT ADAPTER RH

1.2 Camera Performance Specifications

Table 3: Camera Performance Specifications

Feature / Specification	2k	4k
Imager Format	Bilinear CCD	
Resolution	2048 pixels (2046 interpolated)	4096 pixels (4094 interpolated)
Pixel Fill Factor	100%	
Pixel Size	14 x 14 µm	10 x 10 µm
Antiblooming	100x	
Gain Range	0 to 20 dB	
Optical Interface	**2k**	**4k**
Lens opening	M42 x 1 thread, depth 4.0 mm	62 mm hole, depth 4.5 mm
Lens mount adapter	M42 x 1, C, F	F, M72 x 0.75
Back Focal Distance	6.56 ± 0.25 mm	
Sensor Alignment		
x	± 50 µm	
y	± 50 µm	
z	± 0.25 mm	
Yz	± 0.2°	
Mechanical Interface	**2k**	**4k**
Camera Size	72(h) x 60(w) x 50(l) mm	85(h) x 65(w) x 50(l) mm
Mass	< 300 g	300 g
Connectors		
power connector	6 pin male Hirose	
data connector	MDR26 female	
Electrical Interface	**2k**	**4k**
Input Voltage	+12 to +15 Volts	
Power Dissipation	<5 W	<7 W
Operating Temperature	0 to 50 °C (front plate)	
Bit Width	8 or 12 bit user selectable Bits	
Output Data Configuration	Base Camera Link	
Speed	**2k**	**4k**
Maximum Line Rate	18 000 Hz	9 000 Hz
Minimum line rate	300 Hz	300 Hz

Table 4: Camera Operating Specifications

Specs	Unit	0 dB			10 dB			+20 dB		
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max
Broadband responsivity	DN / (nJ / cm²)									
2k		—	158	—	—	400	—	—	1264	—
4k		—	79	—	—	250	—	—	490	—
Random noise rms	DN	—	3	6.5	—	9.2	20.5	—	30	65
Dynamic range	DN:DN									
2k		500:1	1400:1	—	203:1	324:1	—	59:1	108:1	—
4k		—	1225:1	—	—	387:1	—	—	122.3:1	—
FPN global	DN p-p									
Uncorrected		—	—	52.8	—	—	169.6	—	—	536
Corrected		—	—	32	—	—	32	—	—	64
PRNU ECD										
Uncorrected local	%	—	—	8.5	—	—	8.5	—	—	11.5
Uncorrected global	%	—	—	10	—	—	10	—	—	10
Corrected local	DN p-p	—	—	80	—	—	80	—	—	95
Corrected global	DN p-p	—	—	80	—	—	80	—	—	95
PRNU ECE										
Uncorrected local	%	—	—	8.5	—	—	12	—	—	37
Uncorrected global	%	—	—	10	—	—	12	—	—	37
Corrected local	DN p-p	—	—	80	—	—	237	—	—	752
Corrected global	DN p-p	—	—	80	—	—	208	—	—	752
SEE (calculated)	nJ/cm²									
		—	12.2	—	—	4.0	—	—	1.2	—
NEE (calculated)	pJ/cm²								—	—
		—	9.2	—	—	9.3	—	—	9.2	—
Saturation output amplitude	DN	—	—	—	—	3968±80	—	—	—	—
DC offset	DN	—	—	96	—	—	160	—	—	336

Test conditions unless otherwise noted:

- 12-bit values, Flat Field Correction (FFC) enabled.
- CCD Pixel Rate: 40 Megapixels/second per sensor tap.
- Line Rate: 5000 Hz.
- Nominal Gain setting unless otherwise specified.
- Light Source: Broadband Quartz Halogen, 3250 k, with 750 nm high-pass filter and BG38 filter installed.
- Ambient test temperature 25 °C.
- Unless specified, all values are referenced at 12 bit.
- Exposure mode disabled.

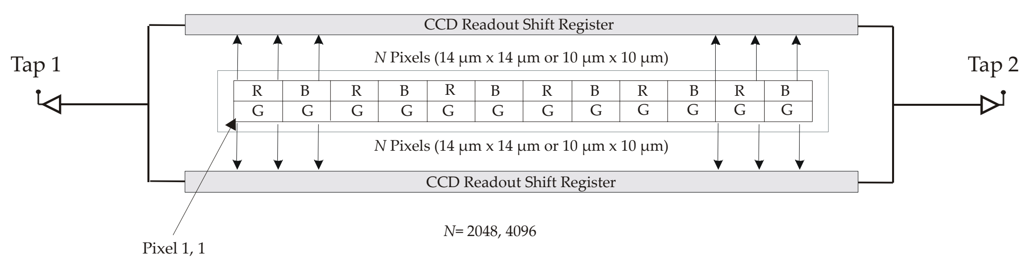
Notes

1. PRNU measured at 50% SAT.

1.3 Image Sensor

The Spyder3 Color bilinear camera is based on DALSA's dual line scan CCD sensor. The bilinear sensor has two lines. The first line has red (R) and blue (B) pixel alternatively, while the second line has all green (G) pixels. There is no gap in between the two lines and this minimizes any artifact due to spatial correction. The G channel can be used as a monochrome output. The sensor has a 2 tap output.

Figure 1: Bilinear sensor used in Spyder3 Color (block diagram)



1.4 Responsivity

Figure 2: Spyder3 Color 2k Responsivity

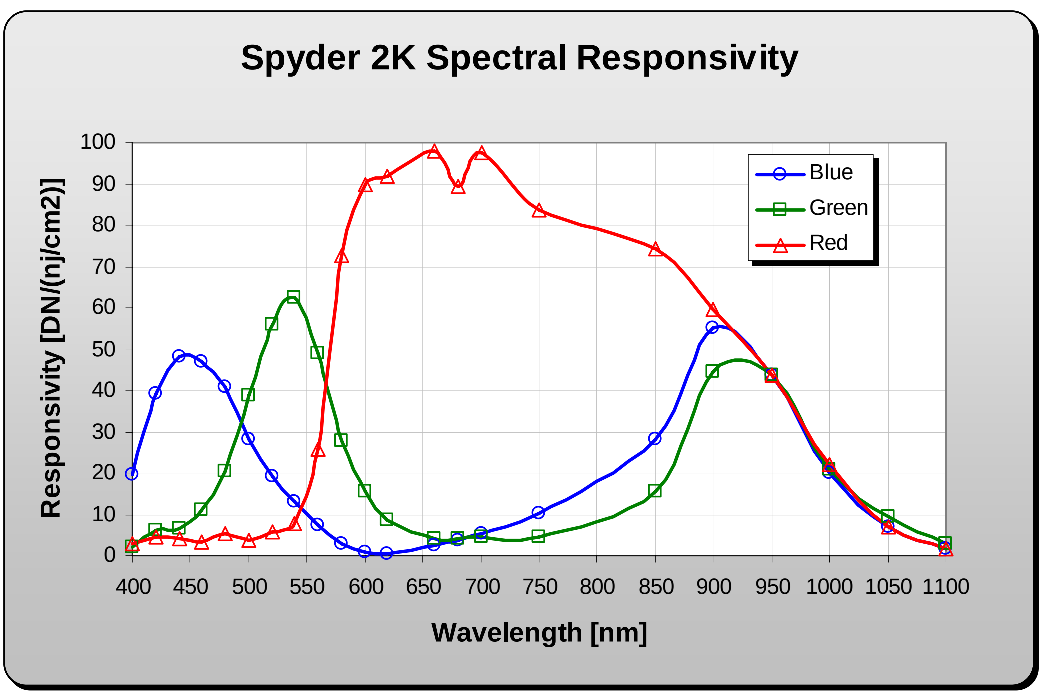
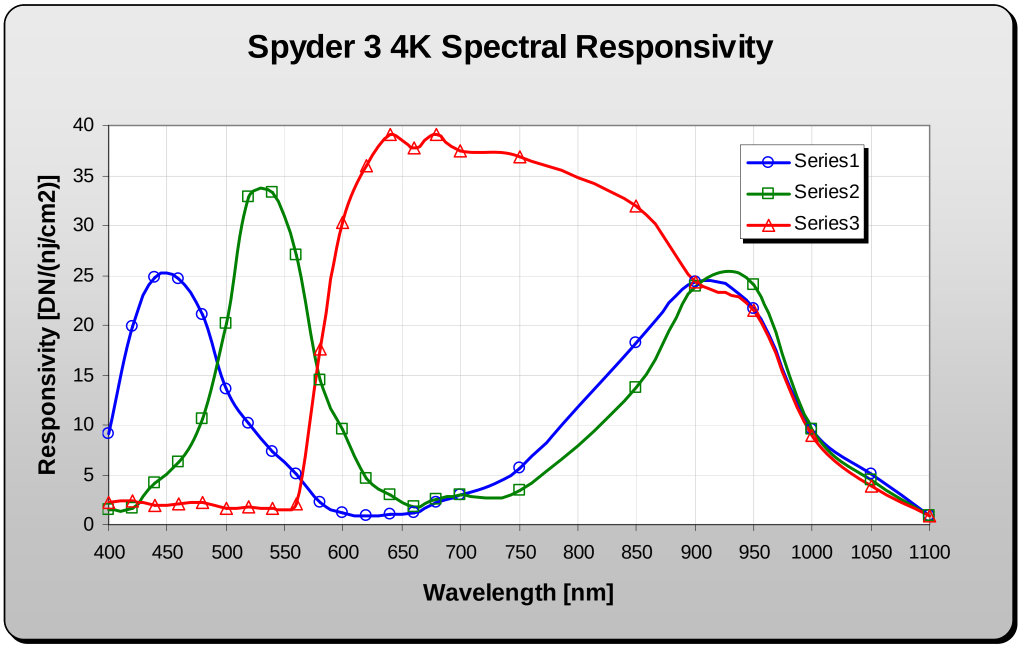


Figure 3: Spyder3 Color 4k Responsivity



2 Setting Up the Camera

2.1 Installation Overview

When installing your camera, you should take these steps:

This installation overview assumes you have not installed any system components yet.

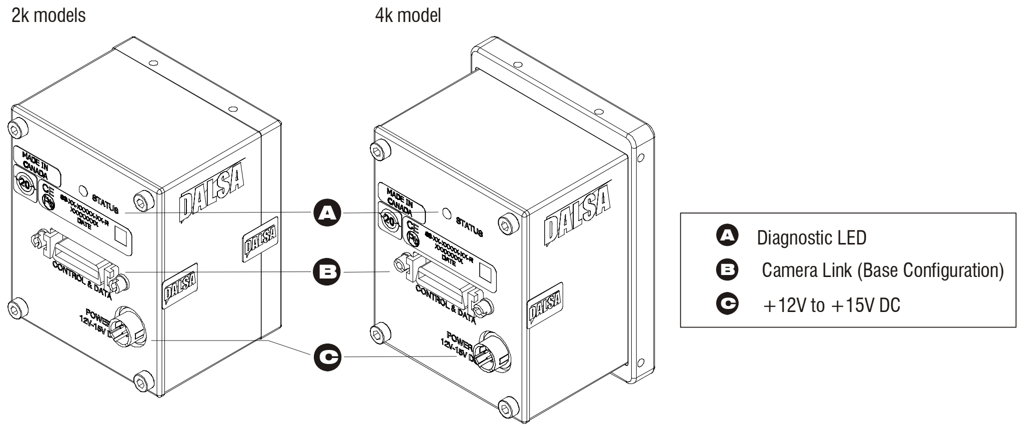
1. Power down all equipment.
2. Follow the manufacturer's instructions and install the frame grabber (if applicable). Be sure to observe all static precautions.
3. Install any necessary imaging software.
4. Before connecting power to the camera, test all power supplies. Ensure that all the correct voltages are present at the camera end of the power cable. Power supplies must meet the requirements defined in section 2.3 Power Connector.
5. Inspect all cables and connectors prior to installation. Do not use damaged cables or connectors or the camera may be damaged.
6. Connect Camera Link and power cables.
7. After connecting cables, apply power to the camera.
8. Check the diagnostic LED. See below for an LED description.

2.2 Input/Output Connectors and LED

The camera uses:

- A diagnostic LED for monitoring the camera.
- High-density 26-pin MDR26 connector for Camera Link control signals, data signals, and serial communications.
- One 6-pin Hirose connector for power.

Figure 4: Input and Output Connectors



WARNING: It is extremely important that you apply the appropriate voltages to your camera. Incorrect voltages may damage the camera. See section 2.4 for more details.

2.3 Power Connector

Figure 5: Hirose 6-pin Circular Male—Power Connector and Table 5: Hirose Pin Description

Pin	Description	Pin	Description
1, 2, 3	Min +12 to Max +15V	4, 5, 6	Ground

The camera requires a single voltage input (+12 to +15 V). The camera meets all performance specifications using standard switching power supplies, although well-regulated linear supplies provide optimum performance.

WARNING: When setting up the camera's power supplies follow these guidelines:

- Apply the appropriate voltages. Ensure +12 V to +15 V at the camera power input (after the voltage drop across the power cable). This may mean that the power suppy may have to provide a voltage greater than the required one, in order to adjust for this loss. For example, to achieve +12 V at the camera, the power supply may need to supply +12.5 V or greater.
- Protect the camera with a fast-blow fuse between power supply and camera.
- Do not use the shield on a multi-conductor cable for ground.
- Keep leads as short as possible to reduce voltage drop.
- Use high-quality linear supplies to minimize noise.

Note: Camera performance specifications are not guaranteed if your power supply does not meet these requirements.

DALSA offers a power supply with attached 6' power cable that meets the Spyder3 Color camera's requirements, but it should not be considered the only choice. Many high quality supplies are available from other vendors. Visit the http://mv.dalsa.com Web site for a list of companies that make power supplies that meet the camera's requirements. The companies listed should not be considered the only choices.

2.4 Camera LED

The camera is equipped with a red/green LED used to display the operational status of the camera. The table below summarizes the operating states of the camera and the corresponding LED states.

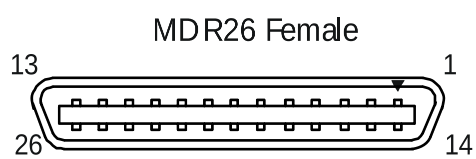
When more than one condition is active, the LED indicates the condition with the highest priority. Error and warning states are accompanied by corresponding messages further describing the current camera status.

Table 6: Diagnostic LED

Priority	Color of Status LED	Meaning
1	Flashing Red	Fatal Error. For example, camera temperature is too high and camera thermal shutdown has occurred. Warning. Loss of functionality (e.g. external SRAM failure).
2	Flashing Green	Camera initialization or executing a long command
3	Solid Green	Camera is operational and functioning correctly
4	Solid Red	Warning. Loss of functionality.

2.5 Camera Link Data Connector

Figure 6: Camera Link MDR26 Connector



**3M part 14X26-SZLB-XXX-0LC is a complete cable assembly, including connectors.
Unused pairs should be terminated in 100 ohms at both ends of the cable.

Mating Part: 3M 334-31 series
Cable: 3M 14X26-SZLB-XXX-0LC**

The Camera Link interface is implemented as Base Configuration in the Spyder3 Color cameras. Refer to section on **Error! Reference source not found.** for details on setting the Camera Link configuration.

Table 7: Camera Link Hardware Configuration Summary

Configuration	8 Bit Ports Supported	Serializer Bit Width	Number of Chips	Number of MDR26 Connectors	Applicable Camera Models
Base	A, B, C	28	1	1	The various models

Table 8: Camera Link Connector Pinout

Base Configuration		
One Channel Link Chip + Camera Control + Serial Communication		
Camera Connector	**Right Angle Frame Grabber**	**Channel Link Signal**
1	1	inner shield
14	14	inner shield
2	25	X0-
15	12	X0+
3	24	X1-
16	11	X1+
4	23	X2-
17	10	X2+
5	22	Xclk-
18	9	Xclk+
6	21	X3-
19	8	X3+
7	20	SerTC+
20	7	SerTC-
8	19	SerTFG-
21	6	SerTFG+
9	18	CC1-
22	5	CC1+
10	17	CC2+
23	4	CC2-
11	16	CC3-
24	3	CC3+
12	15	CC4+
25	2	CC4-
13	13	inner shield
26	26	inner shield

Notes:

*Exterior Overshield is connected to the shells of the connectors on both ends.
**3M part 14X26-SZLB-XXX-0LC is a complete cable assembly, including connectors.
Unused pairs should be terminated in 100 ohms at both ends of the cable.
Inner shield is connected to signal ground inside camera

Table 9: DALSA Camera Control Configuration

Signal	Configuration
CC1	EXSYNC
CC2	PRIN
CC3	Direction

See Appendix B for the complete DALSA Camera Link configuration table, and refer to the DALSA Web site, http://mv.dalsa.com, for the official Camera Link documents.

Input Signals, Camera Link

The camera accepts control inputs through the Camera Link MDR26F connector.

The camera ships in internal sync, maximum exposure time (exposure mode 7).

EXSYNC (Triggers Line Readout)

Line rate can be set internally using the serial interface. The external control signal EXSYNC is optional and enabled through the serial interface. This camera uses the **falling edge of EXSYNC** to trigger pixel readout. See Setting the Exposure Mode, page 32, for details on how to set line rates, exposure times, and camera modes.

Output Signals, Camera Link

These signals indicate when data is valid, allowing you to clock the data from the camera to your acquisition system. These signals are part of the Camera Link configuration and you should refer to the DALSA Camera Link Implementation Road Map, available at http://mv.dalsa.com, for the standard location of these signals.

Clocking Signal	Indicates
LVAL (high)	Outputting valid line
DVAL (high)	Valid data (unused, tied high)
STROBE (rising edge)	Valid data
FVAL (high)	Outputting valid frame (unused, tied high)

The camera internally digitizes 12 bits and outputs the 8 MSB or all 12 bits depending on the camera's Camera Link operating mode.

2.6 Camera Link Video Timing

Figure 7: Overview Timing Showing Input and Output Relationships

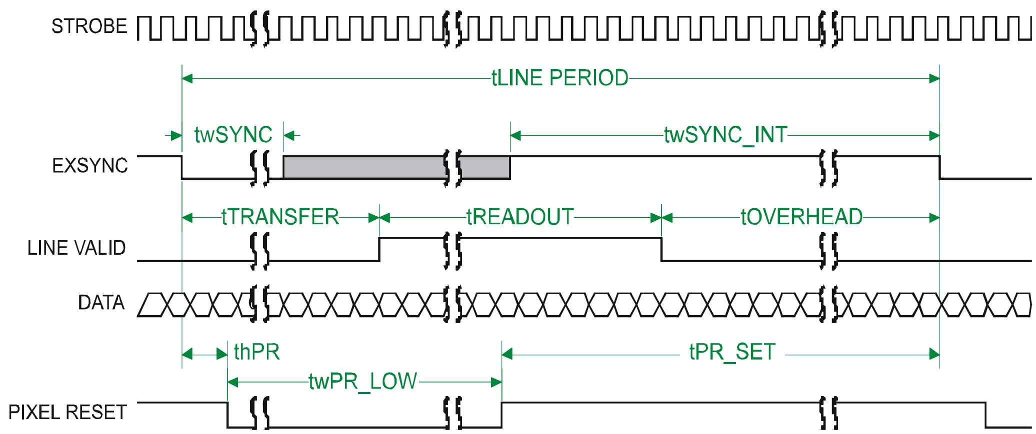


Figure 8: Fixed (Programmed) Integration Timing with External EXSYNC

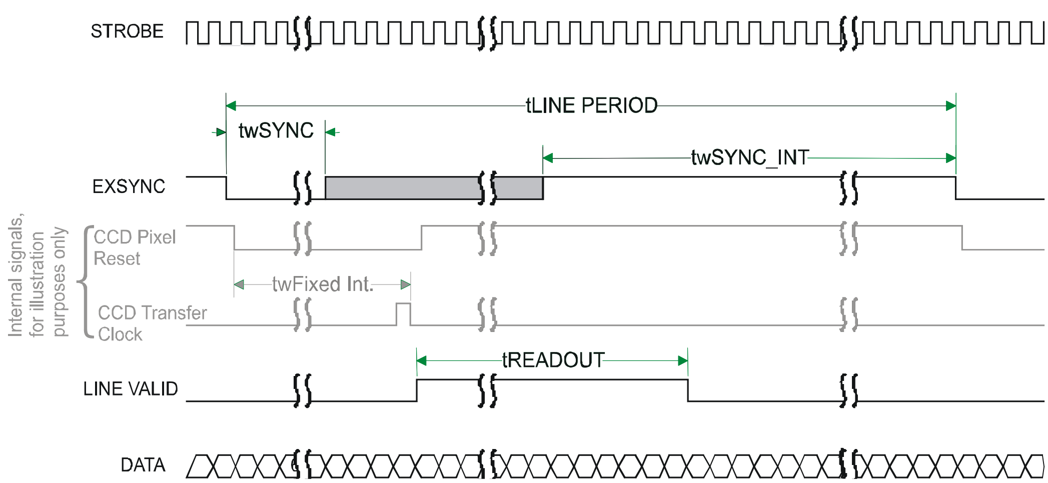


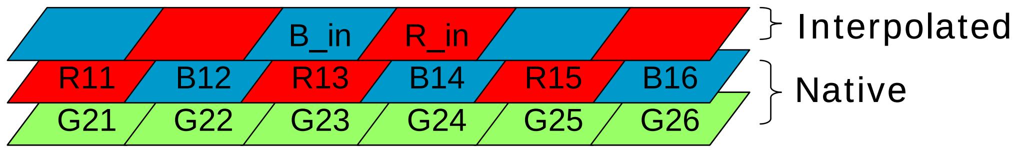
Table 10: Spyder3 Color Input and Output

Symbol	Definition	Min (ns)
twSYNC	The minimum low width of the EXSYNC pulse when not in SMART EXSYNC mode.	100
$twSYNC_{(SMART)}$*	The minimum low width of the EXSYNC pulse when in SMART EXSYNC modes to guarantee the photosites are reset.	3,000
twSYNC_INT	The minimum width of the high pulse when the "SMART EXSYNC" feature is turned off	100
twSYNC_INT (SMART) *	Is the integration time when the "SMART EXSYNC" feature is available and turned on. Note that the minimum time is necessary to guarantee proper operation.	3,000
tLINE PERIOD (t_{LP})	The minimum and maximum line times made up of tTransfer, tREADOUT plus tOVERHEAD to meet specifications.	27,778 (2k 2 tap) 55,775 (4k 2 tap)
tTransfer	The time from the reception of the falling edge of EXSYNC to the rising edge of LVAL when pretrigger is set to zero. Pretrigger reduces the number of clocks to the rising edge of LVAL but doesn't change the time to the first valid pixel. If the fixed integration time mode of operation is available and selected then the integration time is added to the specified value.	3,725 ±25 (2k) 4,100±25 (4k)
twFixed Int.	Fixed Integration Time mode of operation for variable exsync frequency.	800
tREADOUT	Is the number of pixels per tap times the readout clock period.	25,600 (2k 2 tap) 51,200 (4k 2 tap)
tOVERHEAD	Is the number of pixels that must elapse after the falling edge of LVAL before the EXSYNC signal can be asserted. This time is used to clamp the internal analog electronics	425±25 (All models)
twPR_LOW	Minimum Low time to assure complete photosite reset	3,000
tPR_SET	The nominal time that the photo sites are integrating. Clock synchronization will lead to integration time jitter, which is shown in the specification as +/- values. The user should command times greater than these to ensure proper charge transfer from the photosites. Failure to meet this requirement may result in blooming in the Horizontal Shift Register.	3,000

Camera Output Format

There are several color output formats:

RGB mode (interpolation): camera outputs three colors (two native colors, one interpolated color) for each pixel.



1) RG/BG mode (native): In this mode the camera outputs two native colors per pixel, (RG or BG depending on the pixel location)

2) G mode (native): This mode provides 100% fill factor native green color that can be used as a monochrome channel

3 Optical, Mechanical, and Electrical Considerations

3.1 Mechanical Interface

Figure 9: SC 2k Mechanical Dimensions

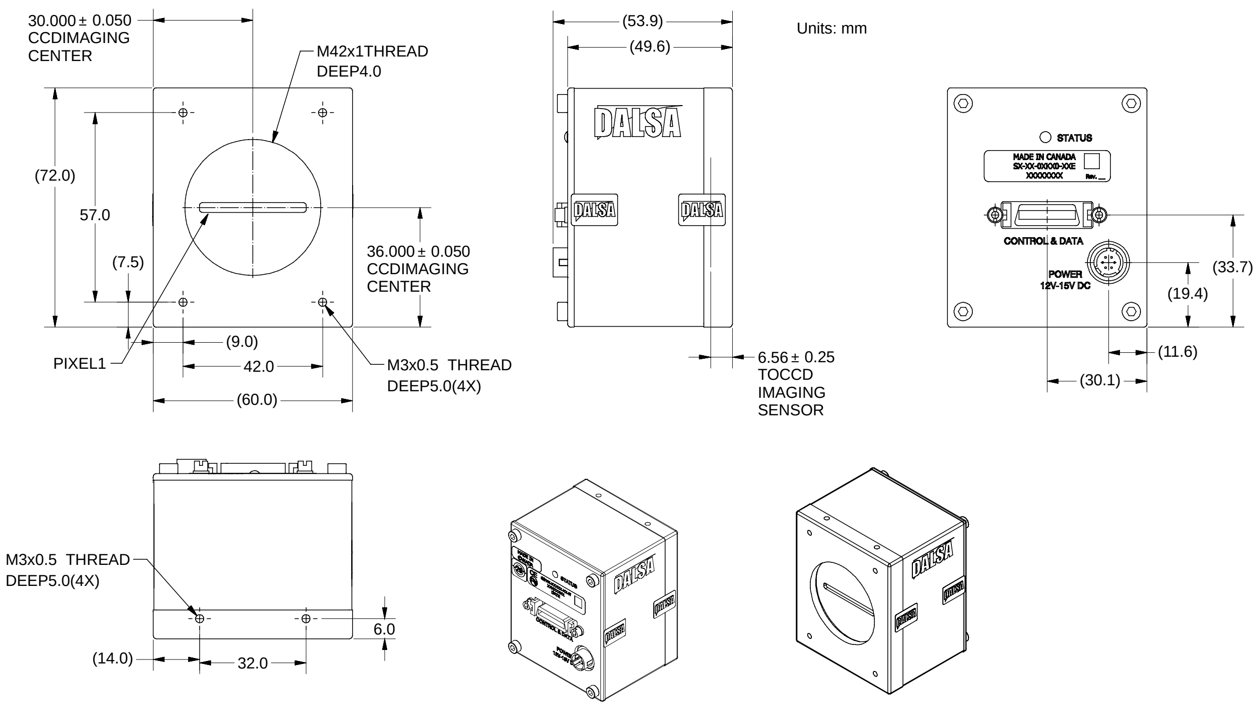
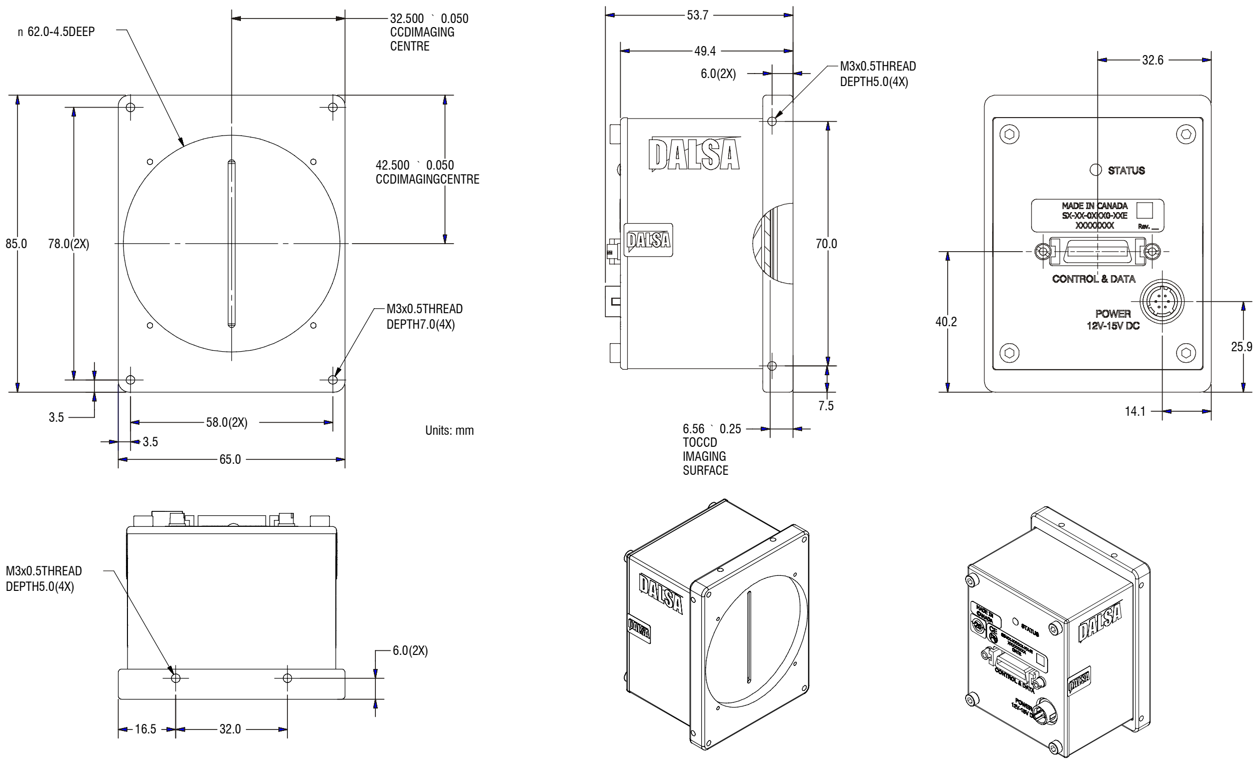


Figure 10: SC 4k Mechanical Dimensions



3.2 Optical Interface

Illumination

The amount and wavelengths of light required to capture useful images depend on the particular application. Factors include the nature, speed, and spectral characteristics of objects being imaged, exposure times, light source characteristics, environmental and acquisition system specifics, and more. DALSA's Web site http://mv.dalsa.com, provides an introduction to this potentially complicated issue. See "Radiometry and Photo Responsivity" and "Sensitivities in Photometric Units" in the CCD Technology Primer found under the Application Support link.

It is often more important to consider exposure than illumination. The total amount of energy (which is related to the total number of photons reaching the sensor) is more important than the rate at which it arrives. For example, 5 $\mu J/cm^2$ can be achieved by exposing 5 mW/cm^2 for 1 ms just the same as exposing an intensity of 5 W/cm^2 for 1µs.

Light Sources

Keep these guidelines in mind when setting up your light source:

- LED light sources are relatively inexpensive, provide a uniform field, and longer life span compared to other light sources. However, they also require a camera with excellent sensitivity, such as the Spyder3 Color camera.
- Halogen light sources generally provide very little blue relative to infrared light (IR).
- Fiber-optic light distribution systems generally transmit very little blue relative to IR.
- Some light sources age; over their life span they produce less light. This aging may not be uniform—a light source may produce progressively less light in some areas of the spectrum but not others.

Blue Clipping: In most photodiodes, including those in the CCD used in the Spyder 3 Color, the blue color is the least responsive. As a result, in order to maintain white balance the blue color has to be gained up approximately 2 to 3 times more than the red or the green colors. When the user issues a command, such as scg 20 (i.e. gaining up all colors to 20 dB), the total blue gain will max out between 15 dB and 19 dB as a result of it already being gained higher by default (i.e. in the 0 dB gain setting).

Filters

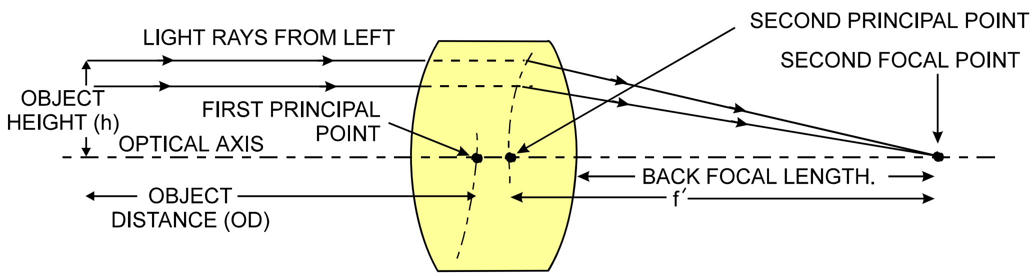
CCD cameras are extremely responsive to infrared (IR) wavelengths of light. To prevent infrared from distorting the images you scan, use a "hot mirror" or IR cutoff filter that transmits visible wavelengths but does not transmit wavelengths over 750 nm. Examples are the Schneider Optics™ B+W 489, which includes a mounting ring, the CORION™ LS-750, which does not include a mounting ring, and the CORION™ HR-750 series hot mirror.

Lens Modeling

Any lens surrounded by air can be modeled for camera purposes using three primary points: the first and second principal points and the second focal point. The primary points for a lens should be available from the lens data sheet or from the lens manufacturer. Primed quantities denote characteristics of the image side of the lens. That is, *h* is the object height and *h′* is the image height.

The *focal point* is the point at which the image of an infinitely distant object is brought to focus. The *effective focal length (f′)* is the distance from the second principal point to the second focal point. The *back focal length (BFL)* is the distance from the image side of the lens surface to the second focal point. The *object distance (OD)* is the distance from the first principal point to the object.

Figure 11: Primary Points in a Lens System



Magnification and Resolution

The magnification of a lens is the ratio of the image size to the object size:

$$m = \frac{h'}{h}$$

where m is the magnification, h′ is the image height (pixel size) and h is the object height (desired object resolution size).

By similar triangles, the magnification is alternatively given by:

$$m = \frac{f'}{OD}$$

These equations can be combined to give their most useful form:

$$\frac{h'}{h} = \frac{f'}{OD}$$

This is the governing equation for many object and image plane parameters.

Example: An acquisition system has a 512 x 512 element, 10 µm pixel pitch area scan camera, a lens with an effective focal length of 45 mm, and requires that 100µm in the object space correspond to each pixel in the image sensor. Using the preceding equation, the object distance must be 450 mm (0.450 m).

$$\frac{10\mu m}{100\mu m} = \frac{45mm}{OD} \qquad OD = 450mm\,(0.450m)$$

3.3 Electrical Interface

The Spyder3 Color cameras have been designed for EMC compliance. The test setup has been verified to the following EMC standards:

- CISPR-11:2004
- EN 55011:2003
- EN 61326:2002

To achieve EMC compliance, follow these specific guidelines:

- Ensure that all cable shields have 360° electrical connection to the connector.
- Fasten and secure all connectors.

The camera has also been tested with shock and vibration according to certain requirements specified in MIL-810E.

Controlling the Camera: Interfaces

Camera features can be controlled either through the serial interface or through a GUI interface, see DCT GUI Interface, page 77.

Both options are presented here in the following two sections.

4 Software Interface

4.1 Spyder3 Camera Link ASCII Commands

Serial Interface

All of the camera features can be controlled through the serial interface. The camera can also be used without the serial interface after it has been set up correctly. Functions available include:

- Controlling basic camera functions such as gain and sync signal source
- Flat field correction
- Mirroring and readout control
- Generating a test pattern for debugging

The serial interface uses a simple ASCII-based protocol and the PC does not require any custom software.

Note: This command set may be different from those used by other DALSA cameras. You should not assume that these commands perform the same as those for older cameras.

Serial Protocol Defaults

- 8 data bits
- 1 stop bit
- No parity
- No flow control
- 9.6 kbps
- Camera does not echo characters

Command Format

When entering commands, remember that:

- A carriage return <CR> ends each command.
- A space or multiple space characters separate parameters. Tabs or commas are invalid parameter separators.
- Upper and lowercase characters are accepted
- The backspace key is supported
- The camera will answer each command with either <CR><LF> “OK >" or <CR><LF>"Error xx: Error Message >" or “Warning xx: Warning Message >”. The ">" is used exclusively as the last character sent by the camera.

The following parameter conventions are used in the manual:

- ***i*** = integer value
- ***f*** = real number
- ***m*** = member of a set
- ***s*** = string
- ***t*** = tap id
- ***x*** = pixel column number
- ***y*** = pixel row number

Example: to return the current camera settings

gcp <CR>

Baud Rate

Purpose:	Sets the speed in bps of the serial communication port.
Syntax:	**sbr m**
Syntax Elements:	***m***
	Baud rate. Available baud rates are: **9600** (Default), **19200**, **57600**, and **115200**.
Notes:	Power-on rate is always 9600 baud.
	The **rc** (reset camera) command will *not* reset the camera to the power-on baud rate and will reboot using the last used baud rate.
Example:	**sbr 57600**

4.2 First Power Up Camera Settings

When the camera is powered up for the first time, it operates using the following factory settings:

- Forward CCD shift direction
- RGB color output mode (clm 5)
- Exposure mode 7 (Programmable line rate & max exposure time, 625 µs)
- 1600 Hz line rate

- Readout mode: Auto
- Mirroring mode: 0, left to right
- Factory calibrated analog gain and offset
- 8 bit output

Camera ASCII Command Help

For quick help, the camera can return all available commands and parameters through the serial interface.

There are two different help screens available. One lists all of the available commands to configure camera operation. The other help screen lists all of the commands available for retrieving camera parameters (these are called "get" commands).

To view the help screen listing all of the camera configuration commands, use the command:

Syntax: **h**

To view a help screen listing all of the "get" commands, use the command:

Syntax: **gh**

Notes: For more information on the camera's "get" commands, refer to section 4.18 Returning Camera Settings.

The camera configuration command help screen lists all commands available. Parameter ranges displayed are the extreme ranges available. Depending on the current camera operating conditions, you may not be able to obtain these values. If this occurs, values are clipped and the camera returns a warning message.

Some commands may not be available in your current operating mode. The help screen displays NA in this case.

Parameters
i = integer
f = floating point number
m = member of a set
s = string
t = tap
x = pixel column number
y = pixel row number

Example ASCII Command Help Screen

```
OK>h
ccf  correction calibrate fpn
clm  camera link mode              m      0/1/2/3/5/6/9/10
cpa  calibrate PRNU algorithm      i      1024-4055
css  correction set sample         m      256/512/1024/
cwb  calibrate white balance       i      1024-4055
dpc  display pixel coeffs
efc  enable FPN  coefficients      i      0-1
eil  enable input lut              i      0-1
els  end of line sequence          m      0/3/7
epc  enable PRNU coefficients      i      0-1
gcl  get command log
gcm  get camera model
gcp  get camera parameters
gcs  get camera serial
gcv  get camera version
get  get values                    s
gh   get help
gl   get line
gla  get line average
gsf  get signal frequency          i      1-3
gsl  get status led
```

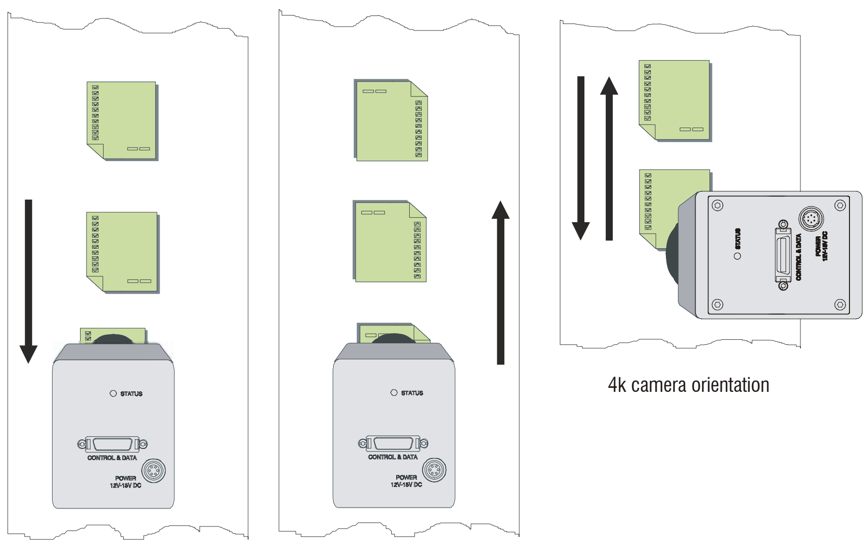
```
h    help
?    single command help         s
lpc  load pixel coefficients
lus  load user settings
rc   reset camera
rpc  reset pixel coeffs
sbr  set baud rate               m      9600/19200/57600/115200/
scc  set color correction        i      -8192-8191
scd  set ccd direction           i      0-2
scg  set colour gain             f      -20.0-20.0
scl  set colour index            m      rgb/r/g/b/
sct  set current tap             t      0-2
scx  set color correction X      m      o/r/g/b
scy  set color correction Y      m      r/g/b/y
sec  set exposure control        m      t/w/m
sem  set exposure mode           m      2/3/4/6/7/8/
set  set exposure time           f      NA
sfs  set ffc selector            m      0/1/2/3/4/5/6/7/8/99
sis  set input [lut] selector    m      0/1/2/3/4/5/6/7/8/99
slm  set line mode               m      i/e
sls  set light source            i      0-4
slt  set lower threshold         i      0-4095
smm  set mirroring mode          i      0-1
spw  set pixel x window width    x      1-2048 or 1-4096
spx  set pixel x postion         x      1-2048 or 1-4096
srm  set readout mode            i      0-2
srw  set roi width               x      1-2048 or 1-4096
srx  set roi x                   x      1-2048 or 1-4096
ssb  set subtract background     i      0-4095
ssf  set sync frequency          f      300-18000
ssg  set system gain             i      0-65535
sus  set user set selector       m      0/1/2/3/4/5/6/7/8/99
sut  set upper threshold         i      0-4095
svm  set video mode              i      0-2
ucr  update color  reference
vt   verify temperature
vv   verify voltage
wfc  write FPN coefficients
wil  write input lut
wpc  write PRNU coefficients
wus  write user settings
```

4.3 Sensor Output Format

Sensor Shift Direction

You can select either forward or reverse CCD shift direction. This accommodates object direction change on a web and allows you to mount the camera “upside down.” The scan direction has no effect on the color output format.

Figure 12: Object Movement and Camera Direction Example using an Inverting Lens



Camera should operate in reverse shift direction scd 1

Camera should operate in forward shift direction scd 0

Note: You can control the CCD shift direction through the serial interface. Use the software command **scd** to determine whether the direction control is set via software control or via the Camera Link control signal on CC3. Refer to the CCD Shift Direction section of this manual, page 29, for details.

CCD Shift Direction

Purpose: Selects the forward or reverse CCD shift direction, internally or externally controlled. This accommodates object direction change on a web and allows you to mount the camera "upside down."

Syntax: **`scd i`**

Syntax Elements: ***`i`***

Shift direction. Allowable values are:

`0 =` Internally controlled, forward CCD shift direction.

`1 =` Internally controlled, reverse CCD shift direction.

`2 =` Externally controlled CCD shift direction via Camera Link control CC3 (CC3=1 forward, CC3=0 reverse).

Notes:

- To obtain the current value of the exposure mode, use the command **`gcp`** or **`get scd.`**
- Refer to Figure 12: Object Movement and Camera Direction Example using an Inverting Lens, page 29, for an illustration of when you should use forward or reverse shift direction.

Example: **`scd 0`**

How to Configure Camera Output

Using the camera link mode and pixel readout direction commands

Use the camera link mode (**`clm`**) command to determine the camera's Camera Link configuration, the number of output taps, and the bit depth. Use the pixel readout direction (**`smm`**) command to select the camera's pixel readout direction.

Setting the Camera Link Mode

Purpose:	Sets the camera's Camera Link configuration, the number of Camera Link taps, and the data bit depth. Refer to the tables on the previous page to determine which configurations are valid for your camera model and how this command relates to other camera configuration commands.
Syntax:	**`clm`** ***`m`***
Syntax Elements:	***`m`*** Output mode to use: **`0`**: G only, 8 bit **`1`**: G only, 10 bit **`2`**: 2 taps (RG/BG), 8 bit output **`3`**: 2 taps (RG/BG), 12 bit output **`5`**: 3 taps (RGB), 8-bit output **`6`**: 3 taps (RGB), 12-bit output (time multiplexed) **`9`**: 4 taps (RGBY), 8-bit output (time multiplexed) **`10`**: 4 taps (RGBY), 12-bit output (time multiplexed)
Notes:	• To obtain the current Camera Link mode, use the command **`gcp`** or **`get clm`**. • The bit patterns are defined by the DALSA Camera Link Roadmap, available from http://mv.dalsa.com. • RGBY is RGB output plus the luminance (set with scx and scy commands)
Example:	**`clm 1`**

4.4 Exposure Mode, Line Rate and Exposure Time

Overview

You have a choice of operating in one of seven modes. The camera's line rate (synchronization) can be generated internally through the software command ssf or set externally with an EXSYNC signal, depending on your mode of operation. To select how you want the camera's line rate to be generated:

1. You must first set the camera mode using the **sem** command.
2. Next, if using mode 2, 7 or 8 use the commands **ssf** and/or **set** to set the line rate and exposure time.

Setting the Exposure Mode

Purpose:	Sets the camera's exposure mode allowing you to control your sync, exposure time, and line rate generation.
Syntax:	`sem i`
Syntax Elements:	*i* Exposure mode to use. Factory setting is **7**.
Notes:	• Refer to Table 11: Spyder3 Color Exposure Modes for a quick list of available modes or to the following sections for a more detailed explanation. • To obtain the current value of the exposure mode, use the command **gcp** or `get sem`.
Related Commands:	**ssf**, **set**
Example:	`sem 3`

Table 11: Spyder3 Color Exposure Modes

Mode	SYNC	PRIN	Programmable Line Rate	Programmable Exposure Time	Description
2	Internal	Internal	Yes	Yes	Internal line rate and exposure time. Exposure control enabled (ECE).
3	External	Internal	No	No	Maximum exposure time. Exposure control disabled (ECD).
4	External	Internal	No	No	Smart EXSYNC. ECE.
6	External	Internal	No	Yes	Fixed integration time. ECE.
7	Internal	Internal	Yes	No	Internal line rate, maximum exposure time. ECD.
8	Internal	Internal	No	Yes	Maximum line rate for exposure time. ECE.

Note: When setting the camera to external signal modes, EXSYNC and/or PRIN must be supplied.

Exposure Modes in Detail

Mode 2: Internally Programmable Line Rate and Exposure Time (Factory Setting)

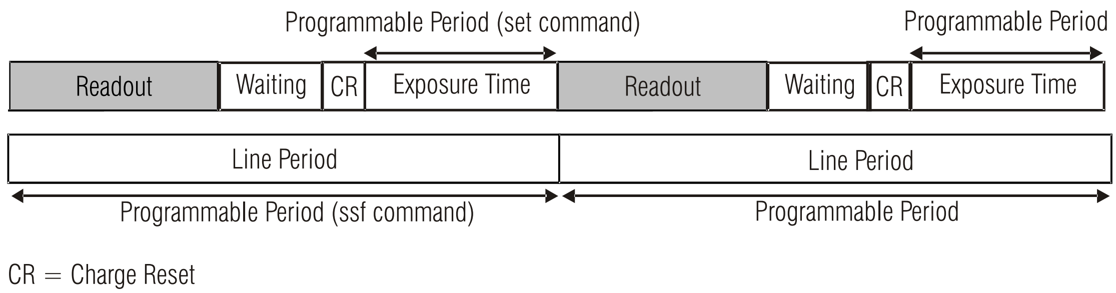
Mode 2 operates at a maximum line rate and exposure time.

- When setting the line rate (using the `ssf` command), exposure time will be reduced, if necessary, to accommodate the new line rate. The exposure time will always be set

to the maximum time (line period – line transfer time – pixel reset time) for that line rate when a new line rate requiring reduced exposure time is entered.

- When setting the exposure time (using the **`set`** command), line time will be increased, if necessary, to accommodate the exposure time. Under this condition, the line time will equal the exposure time + line transfer time.

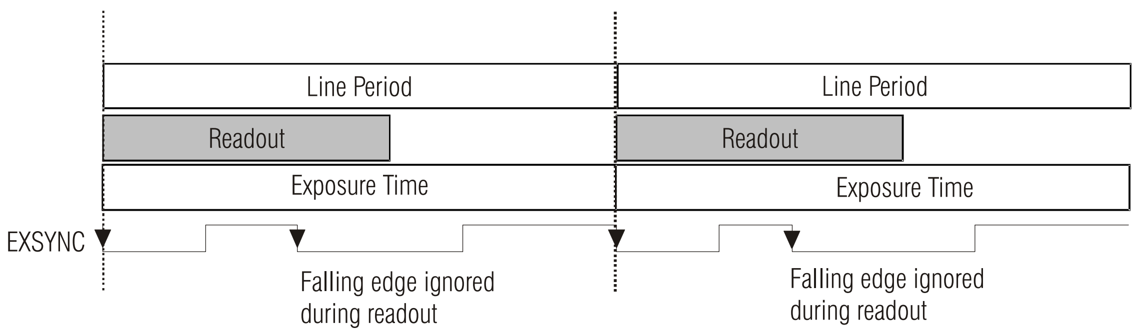
Example 1: Exposure Time Less than Line Period



Mode 3: External Trigger with Maximum Exposure

Line rate is set by the period of the external trigger pulses. The falling edge of the external trigger marks the beginning of the exposure.

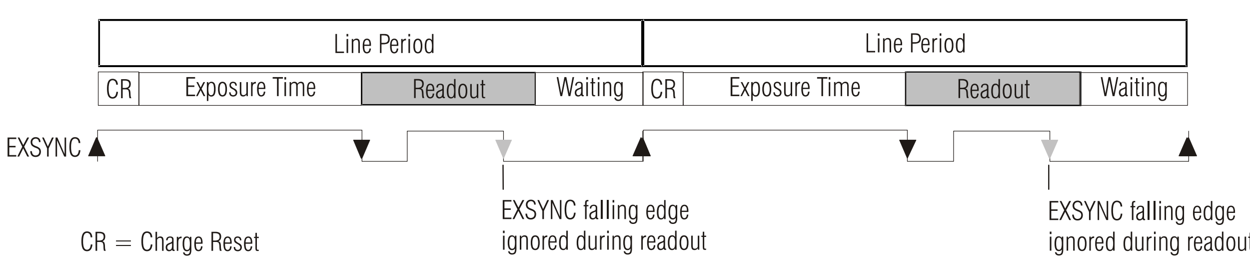
Example 2: Line Rate is set by External Trigger Pulses.



Mode 4: Smart EXSYNC, External Line Rate and Exposure Time

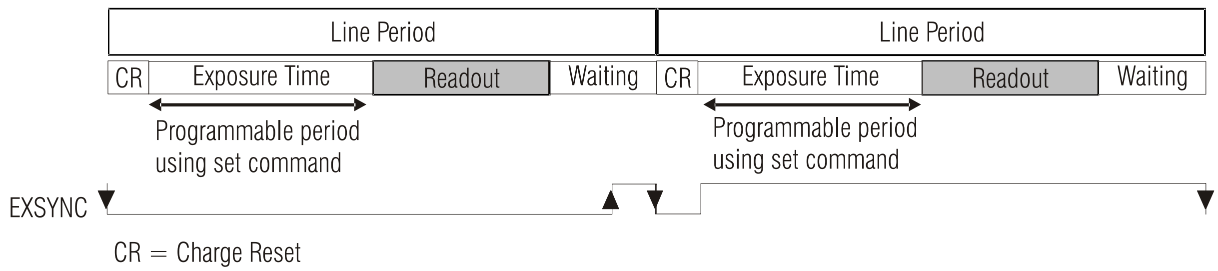
In this mode, EXSYNC sets both the line period and the exposure time. The rising edge of EXSYNC marks the beginning of the exposure and the falling edge initiates readout.

Example 3: Trigger Period is Repetitive and Greater than Read Out Time.



Mode 6: External Line Rate and Internally Programmable Exposure Time

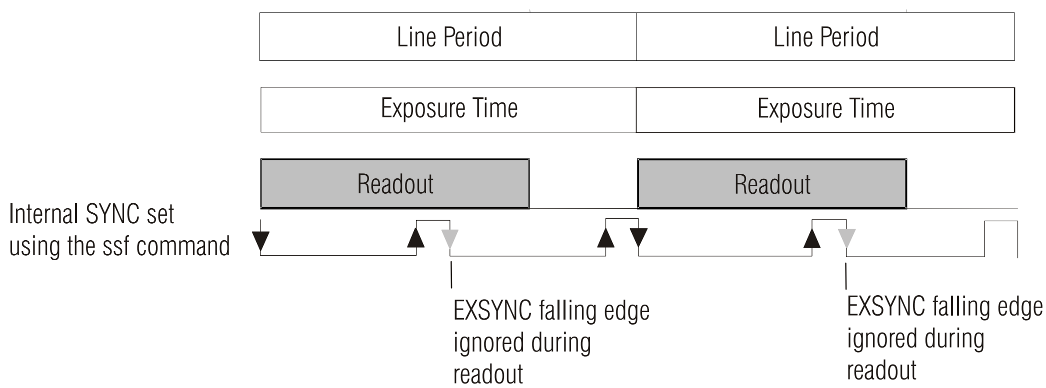
Figure 13: EXSYNC controls Line Period with Internally controlled Exposure Time



Mode 7: Internally Programmable Line Rate, Maximum Exposure Time

In this mode, the line rate is set internally with a maximum exposure time.

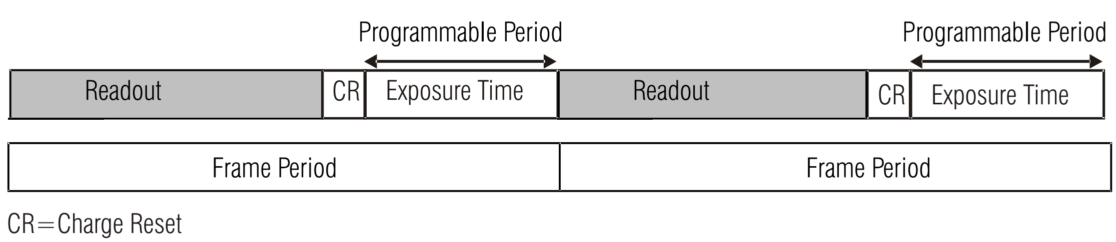
Figure 14: Mode 7 Camera Timing



Mode 8: Maximum Line Rate, Programmable Exposure Time

In this mode, the exposure time is set internally with a maximum line rate.

Figure 15: Mode 8 Timing



Setting the Line Rate

Applies to Modes 2 and 7

Purpose: Sets the camera's line rate in Hz. Camera must be operating in exposure mode 2 or 7.

Syntax: **`ssf f`**

Syntax Elements: **`i`**

Desired line rate in Hz. Allowable values are:
2k 2 tap: **`300 - 18000`** Hz
4k 2 tap: **`300- 9000`** Hz

Notes:

- To read the current line frequency, use the command **`gcp`** or **`get ssf`**.
- If you enter an invalid line rate frequency, an error message is returned.

Related Commands: **`sem, set`**

Example: **`ssf 10000`**

Setting the Exposure Time

Applies to Modes 2 and 8

Purpose: Sets the camera's exposure time is µs. Camera must be operating in exposure mode 2, 6, or 8.

Syntax: **`set f`**

Syntax Elements: **`i`**

Desired exposure time in µs. Allowable range is **`3`** to **`3300`** µs.*

Notes:

- To read the current line frequency, use the command **`gcp`** or **`get set`**.
- If you enter an invalid line rate frequency, an error message is returned.
- *The exposure time range is based on the current line rate.
- To determine the maximum exposure time allowed for the current line rate, use the command **get ger**.

Related Commands: **`sem, ssf`**

Example: **`set 400.5`**

Setting the Pixel Readout Direction (Mirroring Mode)

Purpose:	Sets the tap readout from left to right or from right to left. This command is especially useful if the camera must be mounted upside down.
Syntax:	**smm *i***
Syntax Elements:	***i*** Readout direction. Allowable values are: **0 =** All pixels are read out from left to right. **1 =** All pixels are read out from right to left.
Notes:	• To obtain the current readout direction, use the command **gcp** or **get smm**. • This command is available in both TDI and Area Mode. • Refer to the following figures and tables for an explanation of pixel readout and mirror direction. • Refer to the section below for the sensor architecture diagrams that illustrate the sensor readout direction.
Example:	**smm 1**

Figure 16: Left to Right Readout (smm 0) Forward Direction Example Output

Figure 17: Right to Left Readout (smm 1) Forward Direction Example Output

Note: In clm 2 and clm 3, the output will be R/B/R/B … for smm 0 and B/R/B/R… for smm 1. The green ouput remains the same except mirrored.

Figure 18: Camera Pixel Readout Direction Example using 2k Model with Inverting Lens

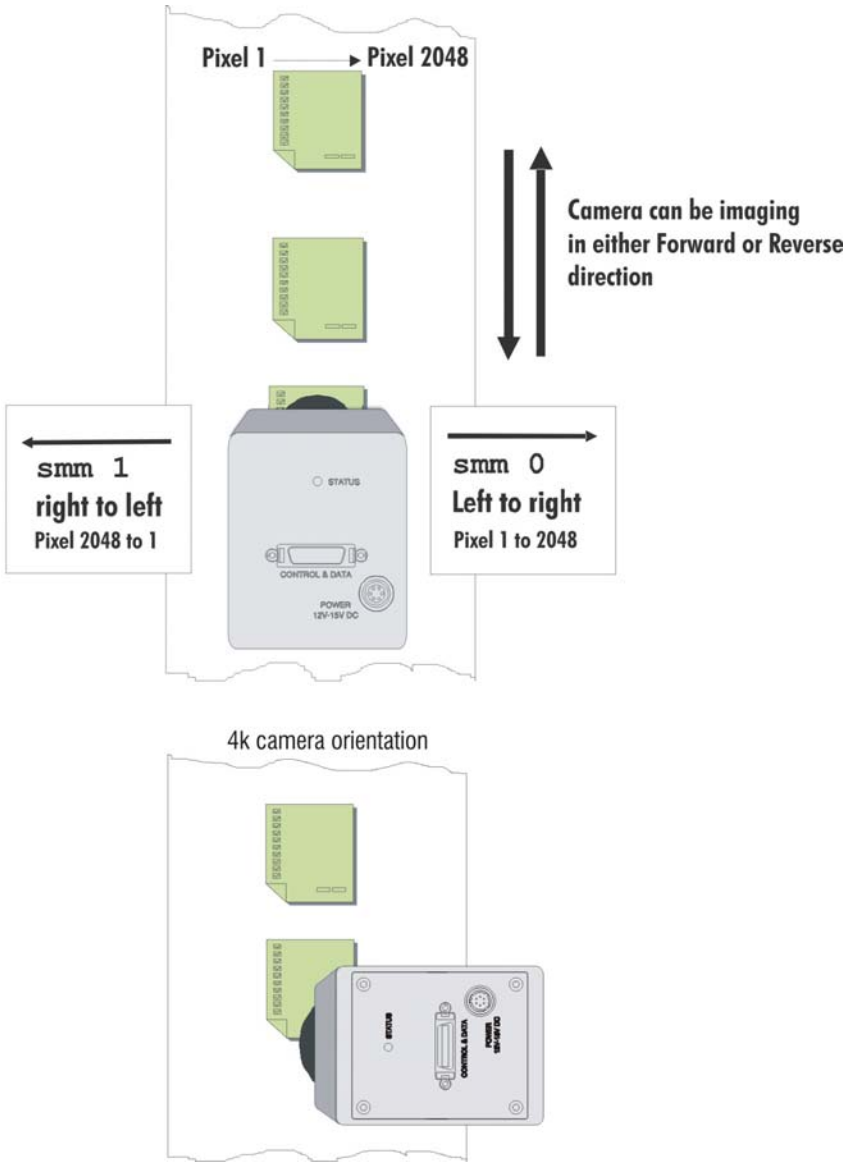


Table 12: Forward or Reverse Pixel Readout

Camera model	Readout direction	Command	Tap 1	Tap 2
SC-30-02K80	Left to Right	`smm 0`	1-1024	1025-2048
	Right to Left	`smm 1`	2048-1025	1024-1
SC-30-04K80	Left to Right	`smm 0`	1-2048	2049-4096
	Right to Left	`smm 1`	4096-2049	2048-1

Setting the Readout Mode

See also, the Clearing Dark Current section in Appendix A for more information on this mode.

Purpose: Use this command to clear out dark current charge in the vertical transfer gates immediately before the sensor is read out.

Syntax: **`srm`**

Syntax Elements: **`i`**

`0`: Auto. Clears dark current below ~ 45% of the maximum line rate.

`1`: Dark current clear. Always clears dark. Reduces the maximum line rate.

`2`: Immediate readout. Does not clear dark current. (Default mode.)

Notes:

- The vertical transfer gates collect dark current during the line period. This collected current is added to the pixel charge. The middle two red taps have more vertical transfer gates and, therefore, more charge. This additional charge is especially noticeable at slower line rates.
- If the user is in **`sem 2`** or **`7`** and **`srm 2`**, with **`ssf`** at 45% of the maximum, and then srm 1 is selected, the following warning will be displayed, but the ssf value will not be changed: Warning 09: Internal line rate inconsistent with readout time> The effect in both internal and external line rate modes is that an EXSYNC is skipped and, therefore, the output will be at least twice as bright.
- This value is saved with the camera settings.
- This value may be viewed using either the **`gcp`** command or the get **`srm`** command.

Related Commands: **`sem, ssf`**

Example: **`srm 0`**

Enabling Line Delay

Purpose: Turning off line delay may result in a better image when you are imaging a web that is moving extremely fast.

Syntax: **`eld`**

Syntax Elements: **`i`**

`0`: Off.

`1`: On.

Example: **`eld 0`**

4.5 Color Commands

Calibrate White Balance

Purpose:	Adjust color digital gain in order to make the color output be a given value while imaging a white reference.
Syntax:	`cwb i`
Syntax Elements:	`i`
	color output in a range **1024** to **4055**.
Example:	`cwb 1024`

Setting Color Correction

Purpose:	Set the value in the color matrix that is multiplied at the end of the digital processing. This matrix corrects the digital output in order to achieve accurate colors.
Syntax:	`scc i`
Syntax Elements:	`i`
	-8192 to 8191
Related Commands	**scx**, **scy**
Example:	`scc 4323`

Setting Color Gain

Purpose:	Set color gain for the current color in a range of **0** to **20 dB**. The current color is set using the **scl** command.
Syntax:	`scg i`
Syntax Elements:	`i`
	0 to **20 dB**.
Related Commands	**scl**
Example:	`scg 10`

Setting Color Selector

Purpose:	Used to select the color for a gain application.
Syntax:	`scl m`
Syntax Elements:	`m`
	rgb/r/g/b
Related Commands	**scg**
Example:	`scl b`

Setting Color Correction X Index

Purpose:	Set the current color correction X index. This command is used to assist the **scc** command.
Syntax:	`scx m`
Syntax Elements:	`m`
	o/r/g/b
Related Commands	**scc**
Example:	`scx b`

Setting Color Correction Y index

Purpose:	Set the current color correction Y index. This command is used to assist the **scc** command.
Syntax:	`scy m`
Syntax Elements:	`m`
	r/g/b/y
Related Commands	**scc**
Example:	

The following is how the **gcp** table entries look for the **scx** and **scy** commands:

Color Correction:	O	r	g	b
r	0	4096	0	0
g	0	0	4096	0
b	0	0	0	4096
y	0	0	0	0

scx selects the column in the above table (either o/r/g/b), scy selects the row (either r/g/b/y) in the above table.

The scc command is what sets the value at the select x and and y position in the table

R_IN, G_IN and B_IN below in the equations are the already digitally processed data.

RED PIXEL OUTPUT = R_IN*(scc # in position [scx r, scy r])/4096 + G_IN*(scc # in position [scx g, scy r])/4096 + B_IN*(scc # in position [scx b, scy r])/4096 + scc # in position [scx o, scy r]

GREEN PIXEL OUTPUT = R_IN*(scc # in position [scx r, scy g])/4096 + G_IN*(scc # in position [scx g, scg r])/4096 + B_IN*(scc # in position [scx b, scy g])/4096 + scc # in position [scx o, scg r]

BLUE PIXEL OUTPUT = R_IN*(scc # in position [scx r, scy b])/4096 + G_IN*(scc # in position [scx g, scy b])/4096 + B_IN*(scc # in position [scx b, scy b])/4096 + scc # in position [scx o, scy b]

Y PIXEL OUTPUT = R_IN*(scc # in position [scx r, scy y])/4096 + G_IN*(scc # in position [scx g, scy y])/4096 + B_IN*(scc # in position [scx b, scy y])/4096 + scc # in position [scx o, scy y]

4.6 Data Processing

Setting a Region of Interest (ROI)

Purpose:	Sets the pixel range used to collect the end-of-line statistics and sets the region of pixels used in the **`gl`**, **`gla`**, and **`ccf`** commands. In most applications, the field of view exceeds the required object size and these extraneous areas should be ignored. It is recommended that you set the region of interest a few pixels inside the actual useable image.
Syntax:	**`srx i`** **`srw i`**
Syntax Elements:	**`srx i`** Starting x position of the ROI, in a value of **`1`** to **`sensor resolution`**. **`srw i`** Width of the ROI, in a value of **`1`** to **`sensor resolution`**.
Notes:	• To return the current region of interest, use the commands **`gcp`** or **`get srx, get srw`**.
Related Commands	**`gl`**, **`gla`**, **`ccf`**, **`cpa, els`**

4.7 Analog and Digital Signal Processing Chain

Please note: description is **preliminary** and subject to change.

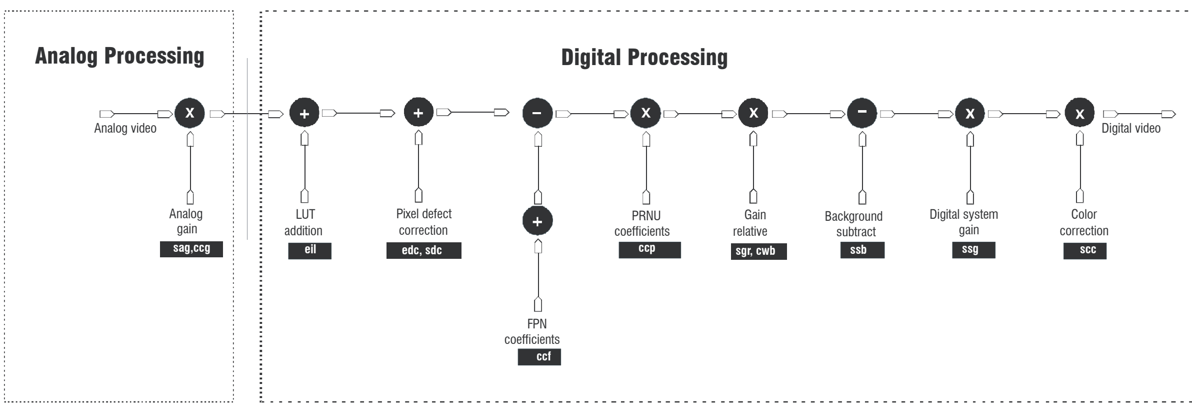
Processing Chain Overview and Description

The following diagram shows a simplified block diagram of the camera's analog and digital processing chain. The analog processing chain begins with an analog gain adjustment, followed by an analog offset adjustment. These adjustments are applied to the video analog signal prior to its digitization by an A/D converter.

The digital processing chain contains the FPN correction, the PRNU correction, the background subtract, and the digital gain and offset. Non-linearity look-up table (LUT) correction is available for the 4k model of camera.

All of these elements are user programmable.

Figure 19: Signal Processing Chain



Analog Processing

Optimizing offset performance and gain in the analog domain allows you to achieve a better signal-to-noise ratio and dynamic range than you would achieve by trying to optimize the offset in the digital domain. As a result, perform all analog adjustments prior to any digital adjustments.

1. Analog gain is multiplied by the analog signal to increase the signal strength before the A/D conversion. It is used to take advantage of the full dynamic range of the A/D converter. For example, in a low light situation the brightest part of the image may be consistently coming in at only 50% of the DN. An analog gain of 6 dB (2x) will ensure full use of the dynamic range of the A/D converter. Of course the noise is also increased. Note: To maintain valid LUT calibration use the `ssg` command.

Digital Processing

To optimize camera performance, digital signal processing should be completed after any analog adjustments.

1. Fixed pattern noise (FPN) calibration (calculated using the **ccf** command) is used to subtract away individual pixel dark current.

2. Photo-Response Non-Uniformity (PRNU) coefficients (calculated using the **cpa** command) are used to correct the difference in responsivity of individual pixels (i.e. given the same amount of light different pixels will charge up at different rates) and the change in light intensity across the image either because of the light source or due to optical aberrations (e.g. there may be more light in the center of the image). PRNU coefficients are multipliers and are defined to be of a value greater than or equal to 1. This ensures that all pixels will saturate together.

3. Background subtract (**ssb** command) and system (digital) gain (**ssg** command) are used to increase image contrast after FPN and PRNU calibration. It is useful for systems that process 8-bit data but want to take advantage of the camera's 12 bit digital processing chain. For example, if you find that your image is consistently between 128 and 255 DN (8 bit), you can subtract off 128 (`ssb 2048`) and then multiply by 2 (`ssg 0 8192`) to get an output range from 0 to 255 DN.

Calibrating the Camera to Remove Non-Uniformity (Flat Field Correction)

Please note: description is **preliminary** and subject to change.

Flat Field Correction Overview

This camera has the ability to calculate correction coefficients in order to remove non-uniformity in the image. This video correction operates on a pixel-by-pixel basis and implements a two-point correction for each pixel. This correction can reduce or eliminate image distortion caused by the following factors:

- Fixed Pattern Noise (FPN)
- Photo Response Non Uniformity (PRNU)
- Lens and light source non-uniformity

Correction is implemented such that for each pixel:

$$V_{output} = [(V_{input} - FPN(\text{ pixel }) - \text{black level offset}) * PRNU(\text{pixel}) – \text{Background Subtract}] \times \text{System Gain}$$

where	V_{output}	=	digital output pixel value
	V_{input}	=	digital input pixel value from the CCD
	PRNU(pixel)	=	PRNU correction coefficient for this pixel
	FPN(pixel)	=	FPN correction coefficient for this pixel
	Background Subtract	=	background subtract value
	System Gain	=	digital gain value

The algorithm is performed in two steps. The fixed offset (FPN) is determined first by performing a calibration without any light. This calibration determines exactly how much offset to subtract per pixel in order to obtain flat output when the CCD is not exposed.

The white light calibration is performed next to determine the multiplication factors required to bring each pixel to the required value (target) for flat, white output. Video output is set slightly above the brightest pixel (depending on offset subtracted).

Note: If your illumination or white reference does not extend the full field of view of the camera, the camera will send a warning.

Flat Field Correction Restrictions

It is important to do the FPN correction first. Results of the FPN correction are used in the PRNU procedure. We recommend that you repeat the correction when a temperature change greater than 10°C occurs or if you change the analog gain, integration time, or line rate.

PRNU correction requires a clean, white reference. The quality of this reference is important for proper calibration. White paper is often not sufficient because the grain in the white paper will distort the correction. White plastic or white ceramic will lead to better balancing.

For best results, ensure that:

- 50 or 60 Hz ambient light flicker is sufficiently low not to affect camera performance and calibration results.
- For best results, the analog gain should be adjusted for the expected operating conditions and the ratio of the brightest to darkest pixel in a tap should be less than 3 to 1 where:

$$3 > \frac{\text{Brightest Pixel (per tap)}}{\text{Darkest Pixel (per tap)}}$$

- The camera is capable of operating under a range of 8 to 1, but will clip values larger than this ratio.
- The brightest pixel should be slightly below the target output.
- When 6.25% of pixels from a single row within the region of interest are clipped, flat field correction results may be inaccurate.
- Correction results are valid only for the current analog gain and offset values. If you change these values, it is recommended that you recalculate your coefficients.

Set up the camera operating environment (i.e. line rate, exposure, offset, gain, etc.)

- Signal output should be no higher than 80% of saturation (i.e. When your output is 12-bit data then 80% of 4096 is 3276. For 8 bit output 80% of 256 is 204).
- Your analog offset setting should not be clipping more than 6.25% of the pixels within the region of interest.
- Digital system gain and background subtract values should be set to zero (**ssg 0 0, ssb 0 0**).

Set the calibration sample size using the command css. It is recommended that you use the default setting.

Set the region of interest to include all of the image's pixels of importance using the command roi x1 y1 x2 y2. You can use the default if you want to calibrate all pixels.

Perform FPN calculation

FPN calculation removes the fixed pattern noise(dark current) from the video path. It is recommended you repeat the calculation when a temperature change greater than 10°C occurs or when there is a significant change in integration time or analog gain.

1. Stop all light from entering the camera. (Tip: Cover lens with a lens cap.)
2. Verify that the output signal level is within range by issuing the command **gl** or **gla**. If there are too many zeros in the output data (more than 6.25% of output data within the roi) , use the automated algorithm **cao 0 i**.
   If the average of the pixels is too high for your application, reduce the analog offset or gain level (**sag**).
3. Issue the command **ccf**.The camera will respond with OK> (if no error occurs). FPN calculation automatically calibrates FPN coefficients and digital offset.
4. After the calibration is complete, you should save these settings to non-volatile memory so they be reusable on reboot. To do so, issue the commands **wfc** and **wus**.
5. To verify output, enable the FPN coefficients using the command **efc 1.** You should see close to zero output.

Perform PRNU calculation

Perform PRNU calculation next to determine the multiplication factors required to bring each pixel to the required value (balance target) for flat, white output.

1. Place a white reference in front of the camera.
2. Verify that the output signal level is within range by issuing the command**gl** or **gla**. If the signal level is too low, increase your light level, adjust the analog gain (**sag**) or use the automated algorithm **ccg i 0 i**.
   DALSA recommends a target value of about 80% of saturation. If you change the gain, FPN coefficients should be recalculated.
3. Issue the command **ccp**. The camera will respond with OK>(if no error occurs).
4. After the calculation is complete, you can save these settings to non-volatile memory so they will be remembered after power-down and direction change. To do so, issue the commands **wpc** and **wus.**
5. Enable the coefficients using the command, **epc 1.**

Note: The commands listed above are described in detail in the following sections.

Analog Signal Processing

Black Level Offset Algorithm: Inherent to the A/D is an offset that is added to the video in order to eliminate video clipping in dark (the offset is also affected by temperature). The Spyder3 Color Cameras have an automatic subtraction of this offset, which is called the Black Level Offset Algorithm. This subtraction helps prevent any unwanted color shift. For example, if the offset is 15 DN in 12-bit multiplying by max gain (20 dB) will give 300 DN (12-bit) offset in the final value. With Black Level Offset digital gain only affects the color signal and not the underlining analog offset. The sole job of the Black Level Offset Algorithm is to keep the offset around 0 DN regardless of analog offset setting or the change in dark current (temperature). 0 DN offset is desirable because you do not want your color gains changing your offsets for each color.

Digital Signal Processing

To optimize camera performance, digital signal processing should be completed after any analog adjustments.

FPN Correction

Performing FPN Correction

Syntax:	Performs FPN correction and eliminates FPN noise by removing individual pixel dark current.
Syntax:	**`ccf`**
Notes:	• Perform all analog and digital adjustments before performing FPN correction. • Perform FPN correction before PRNU correction. • Refer to Calibrating the Camera to Remove Non-Uniformity (Flat Field Correction) on page 43 for a procedural overview on performing flat field correction. • To save FPN coefficients after calibration, use the **`wfc`** command. Refer to section 4.10 Saving and Restoring PRNU and FPN Coefficients for details.
Related Commands:	**`wfc`**
Example:	**`ccf`**

PRNU Correction

Performing PRNU to a user entered value

Purpose: Performs PRNU calibration to user entered value and eliminates the difference in responsivity between the most and least sensitive pixel, creating a uniform response to light. Using this command, you must provide a calibration target.

Executing these algorithms causes the **`ssb`** command to be set to **`0`** (no background subtraction) and the **`ssg`** command to **`4096`** (unity digital gain). The pixel coefficients are disabled (**`epc 0 0`**) during the algorithm execution but returned to the state they were in prior to command execution.

Syntax: **`cpa`** ***`i i`***

Syntax Elements: ***`i`***

PRNU calibration algorithm to use:

`2` = Calculates the PRNU coefficients using the entered target value as shown below:

$$\text{PRNU Coefficient}_i = \frac{\text{Target}}{(\text{AVG Pixel Value}_i)}$$

The calculation is performed for all sensor pixels but warnings are only applied to pixels in the region of interest. This algorithm is useful for achieving uniform output across multiple cameras. It is important that the target value (set with the next parameter) is set to be at least equal to the highest pixel across all cameras so that all pixels can reach the highest pixel value during calibration.

`i`

Peak target value in a range from 1024 to 4055DN. The target value must be greater than the current peak output value.

Notes:

- Perform all analog adjustments before calibrating PRNU.
- Calibrate FPN before calibrating PRNU. If you are not performing FPN calibration then issue the **`rpc`** (reset pixel coefficients) command.

Example: **`cpa 1 600`**

Subtracting Background

Purpose: Use the background subtract command after performing flat field correction if you want to improve your image in a low contrast scene. It is useful for systems that process 8 bit data but want to take advantage of the camera's 12 bit digital processing chain. You should try to make your darkest pixel in the scene equal to zero.

Syntax: **`ssb`** ***`i`***

Syntax Elements: **`i`**

Subtracted value in a range in DN from **`0`** to **`4095`**.

Notes:

- When subtracting a digital value from the digital video signal the output can no longer reach its maximum. Use the **ssg** command to correct for this where:

$$\text{ssg value} = \frac{\text{max output value}}{\text{max output value - ssb value}}$$

See the following section for details on the **ssg** command.

Related Commands: **ssg**

Example **ssb 25**

Setting Digital System Gain

Purpose: Improves signal output swing after a background subtract. When subtracting a digital value from the digital video signal, using the **ssb** command, the output can no longer reach its maximum. Use this command to correct for this where:

$$\text{ssg value} = \frac{\text{max output value}}{\text{max output value - ssb value}}$$

Syntax: **ssg *i***

Syntax Elements: **i**

Gain setting. The gain ranges are **0** to **65535**. The digital video values are multiplied by this value where:

$$\text{Digital Gain} = \frac{i}{4096}$$

Use this command in conjunction with the **ssb** command.

Related Commands: **ssb**

Example: **ssg 15**

Returning Calibration Results and Errors

Returning All Pixel Coefficients

Purpose: Returns all the current pixel coefficients in the order FPN, PRNU, FPN, PRNU… for the range specified by **spx** and **spw**. The camera also returns the pixel number with every fifth coefficient.

Syntax: **dpc**

Notes:

- This function returns all the current pixel coefficients in the order FPN, PRNU, FPN, PRNU… The camera also returns the pixel number with each coefficient.

Enabling and Disabling Pixel Coefficients

Enable FPN coefficients

Purpose:	Enables and disables FPN coefficients.
Syntax:	**`efc i`**
Syntax Elements:	***i*** FPN coefficients. **0** = FPN coefficients disabled **1** = FPN coefficients enabled
Example:	**`efc 1`**

Enable PRNU coefficients

Purpose:	Enables and disables PRNU coefficients.
Syntax:	**`epc i`**
Syntax Elements:	***i*** PRNU coefficients. **0** = PRNU coefficients disabled **1** = PRNU coefficients enabled
Example:	**`epc 0`**

4.8 End-of-line Sequence

Purpose:	Produces an end-of-line sequence that provides basic calculations including "line counter," "line sum," "pixels above threshold," "pixels below threshold," and "derivative line sum" within the region of interest. These calculations can be used to perform **aoc** algorithms or indicate objects of interest. To further aid in debugging and cable/data path integrity, the first three pixels after Line Valid are "aa", "55", "aa". (Refer to the following table.) These statistics are calculated for the pixels within the region of interest.
Syntax:	**`els i`**
Syntax Elements:	**i** **0** Disable end-of-line sequence **3** LVAL extended by 16 (stat) pixels **7** LVAL shifted by 16 pixels to encompass stat pixels
Notes:	• LVAL is high during the end-of-line statistics.
Example:	**`els 1`**

Table 13: End-of-Line Sequence Description

Location	Value	Description
1	A's	By ensuring these values consistently toggle between "aa" and "55", you can verify cabling (i.e. no stuck bits)
2	5's	
3	A's	
4	4 bit counter LSB justified	Counter increments by 1. Use this value to verify that every line is output
5	Line sum (7…0)	Use these values to help calculate line average and gain
6	Line sum (15…8)	
7	Line sum (23…16)	
8	Line sum (31…24)	
9	Pixels above threshold (7…0)	Monitor these values (either above or below threshold) and adjust camera digital gain and background subtract to maximize scene contrast. This provides a basis for automatic gain control (AGC)
10	Pixels above threshold (15…8)	
11	Pixels below threshold (7…0)	
12	Pixels below threshold (15…8)	
13	Differential line sum (7..0)	Use these values to focus the camera. Generally, the greater the sum the greater the image contrast and better the focus.
14	Differential line sum (15…8)	
15	Differential line sum (23…16)	
16	Differential line sum (31…24)	

Setting Thresholds

Setting an Upper Threshold

Purpose: Sets the upper threshold limit to report in the end-of-line sequence.

Syntax: **`sut i`**

Syntax Elements: **`i`**

Upper threshold limit in range from **`0`** to **`4095`**.

Notes:
- LVAL is not high during the end-of-line statistics.

Related Commands:
- **`els`**, **`slt`**

Example: **`sut 1024`**

Setting a Lower Threshold

Purpose:	Sets the lower threshold limit to report in the end-of-line sequence.
Syntax:	**slt *i***
Syntax Elements:	**i** Upper threshold limit in range from **0** to **4095**.
Notes:	• LVAL is not high during the end-of-line statistics.
Related Commands:	• **els**, **sut**
Example:	**slt 1024**

4.9 Saving and Restoring Settings

For each camera operating mode the camera has distinct factory settings, current settings, and user settings. In addition, there is one set of factory pre-calibrated pixel coefficients and up to four sets of user created pixel coefficients for each operating mode.

Factory Settings

On first initialization, the camera operates using the factory settings. You can restore the original factory settings at any time by setting the user set number to the factory setting (**sus 0**) and then loading the user set (**lus**).

User Settings

You can save or restore your user settings to non-volatile memory using the following commands. Pixel coefficients and LUTs are stored separately from other data.

- To save all current user settings to non-volatile memory, use the command **wus**. The camera will automatically restore the saved user settings when powered up. Note: While settings are being written to nonvolatile memory, do not power down camera or camera memory may be corrupted.
- To restore the last saved user settings, use the command **rus**.
- To save the current pixel coefficients, use the command **wpc** and **wfc**.
- To restore the last saved pixel coefficients, use the command **lpc**.
- To write and load LUTs, use the **wil** command.

Current Session Settings

These are the current operating settings of your camera. To save these settings to non-volatile memory, use the command **wus**.

4.10 Saving and Restoring PRNU and FPN Coefficients

Saving the Current PRNU Coefficients

Purpose:	Saves the current PRNU coefficients set using the **sfs** command.
Syntax:	**`wpc`**
Related command:	**`sfs`**

Saving the Current FPN Coefficients

Purpose:	Saves the current FPN coefficients set using the **sfs** command.
Syntax:	**`wfc`**
Releated command:	**`sfs`**

Loading a Saved Set of Coefficients

Purpose:	Loads a saved set of pixel coefficients.
Syntax:	**`lpc`**
Related commands:	**`wpc, wfc, sfs`**

Resetting the Current Pixel Coefficients

Purpose:	Resets the current pixel coefficients to zero. This command does not reset saved coefficients.
Syntax:	**`rpc`**
Notes:	The black level offset is not reset.

Rebooting the Camera

The command **`rc`** reboots the camera. The camera starts up with the last saved settings and the baud rate used before reboot. Previously saved pixel coefficients are also restored.

4.11 Saving and Restoring User Settings Using X-Modem

Use the X-modem feature to save user settings and FPN/PRNU coefficients to a host PC, and vice-versa.

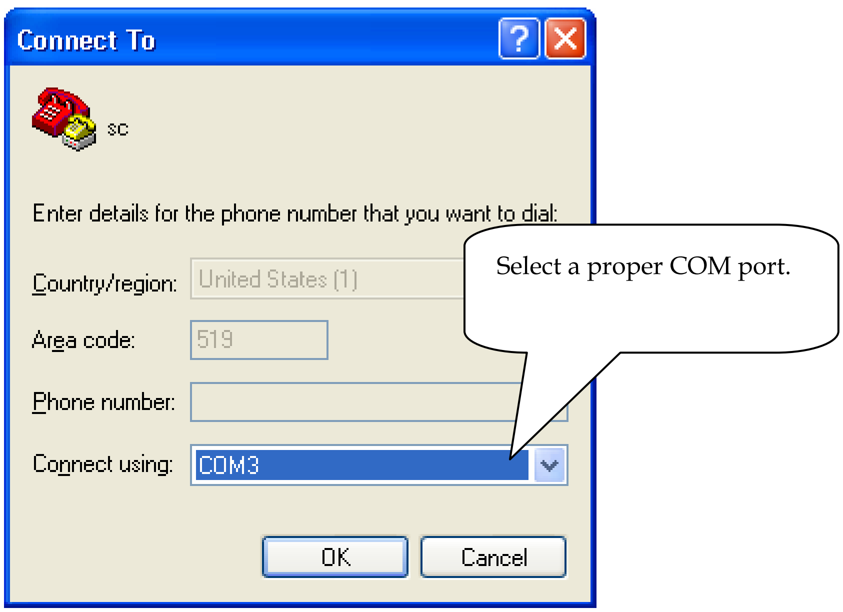
1. HyperTerminal settings

HyperTerminal supports the X-modem communications protocol that is used to upload and download the files. HyperTerminal is the recommended application to use.

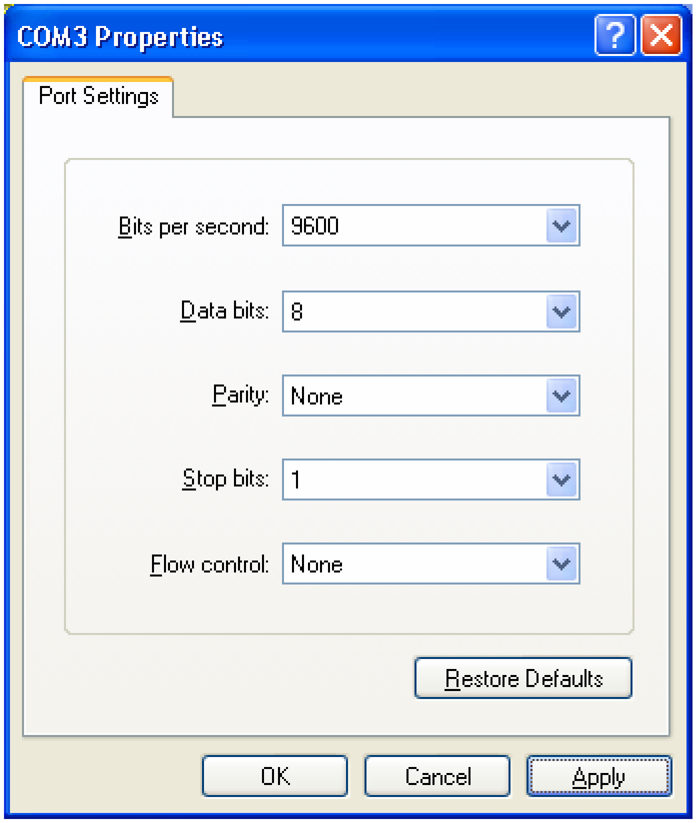
Open HyperTerminal by clicking:

Start→All Programs→Accessories→Communications→HyperTerminal.

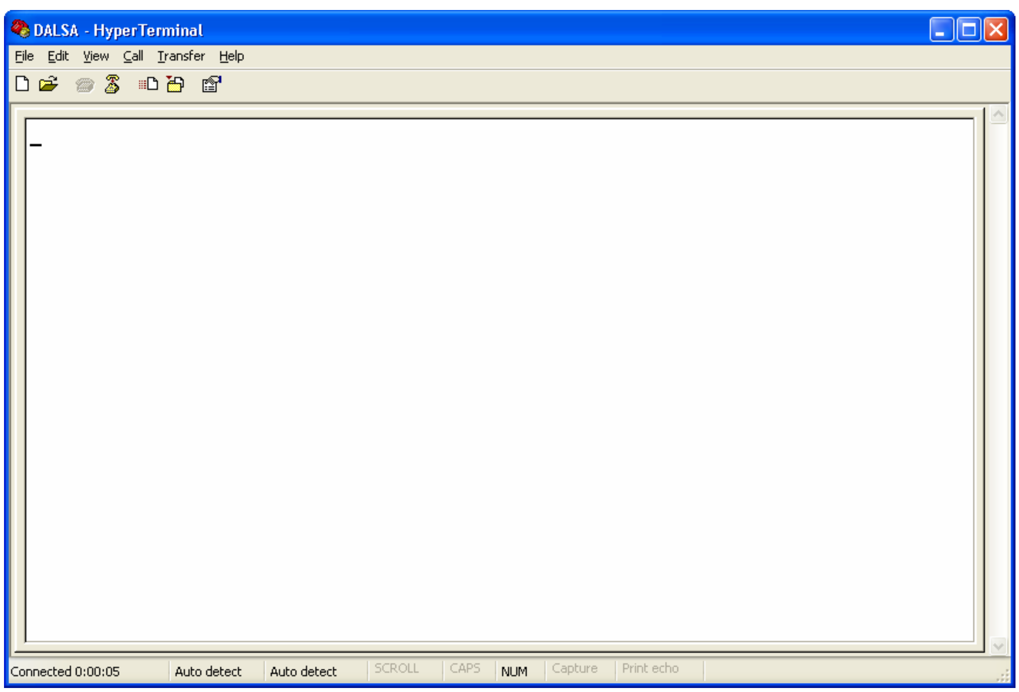
Give your HyperTerminal application a name and click OK. The Connect To dialog box appears.



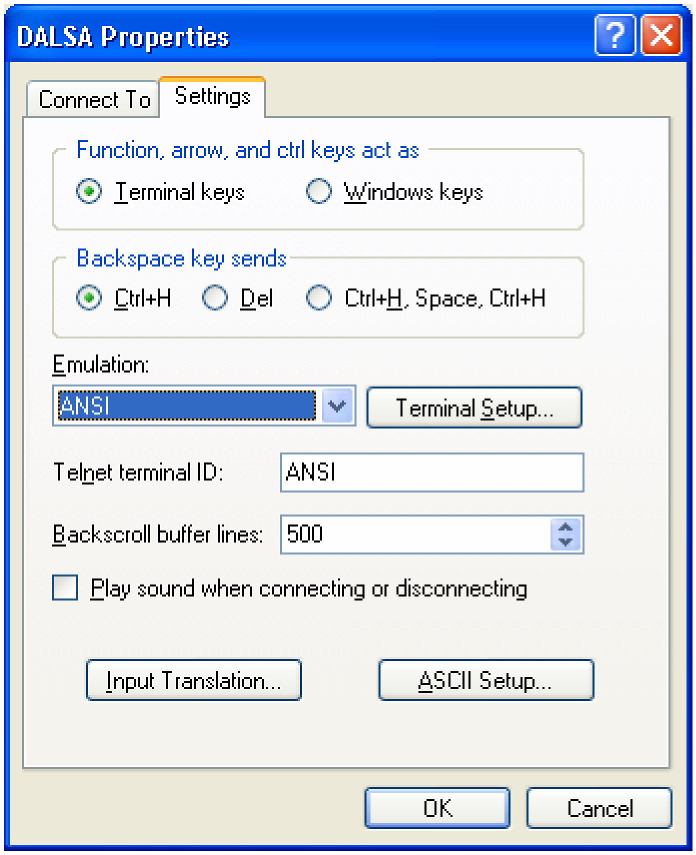
Select a proper COM port and click OK. A COM Properties dialog box appears.



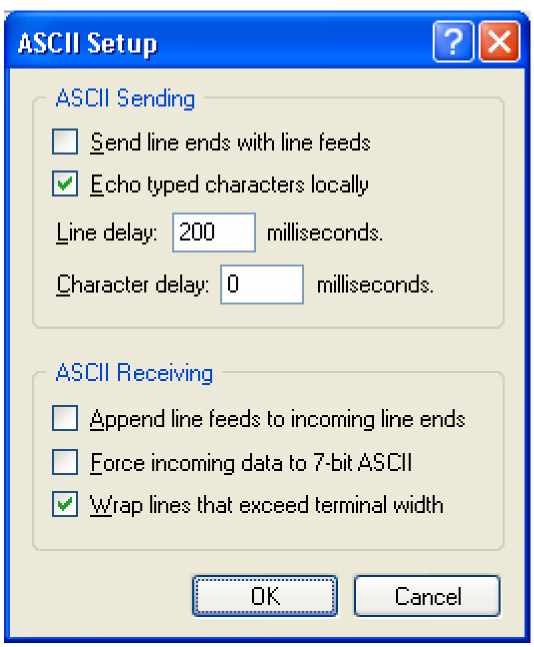
Select each item as shown in the figure above, click Apply, and then OK. The HyperTerminal main dialog box appears.



Select **File → Properties,** or click on the Properties icon and select the **Settings** tab.



Select each item as shown in the figure above, and click the **ASCII Setup**…button.



Set each item as shown in above figure and click OK. Click OK again in the Properties dialog box.

2. Transfer User Settings

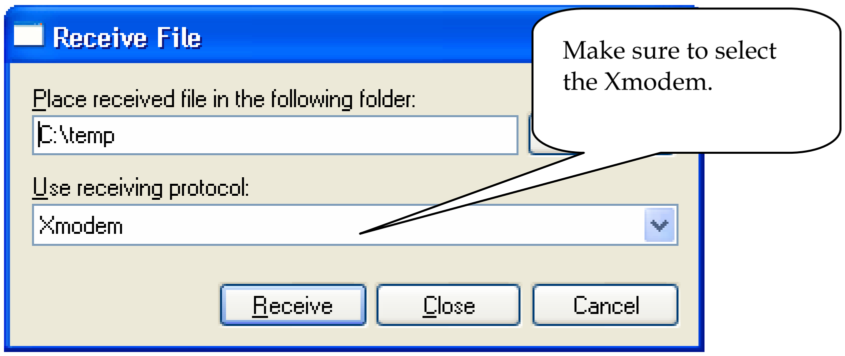
2-1 Save Settings

OK > sus 99

OK > lus

X-Modem Transfer to Host. Camera is ready for sending...

Click **Receive file…** in the Transfer menu to save a settings.



Note that the sus 99 and sfs 99 commands are only communicating to the load commands (lpc and lus) to use the X-Modem transfer. The contents to be transferred are whatever is in the current camera memory (lus) or whatever is transferred to the current camera memory (wus).

For example, if you want to send setting 5 to the host, you communicate: "sus 5", " lus" (these 2 commands load set 5 to memory), and then "sus 99", "lus" (these 2 commands send current set (5) to host). Similarly, if you want to load a settings from a host to set number 5, you communicate: “sus 99”, “wus” (these 2 commands load a settings to current camera memory), and then “sus 5”, “wus” (these to commands transfer settings in current memory to set number (5)).

The same theory is applied to saving and restoring FPN and PRNU coefficients.

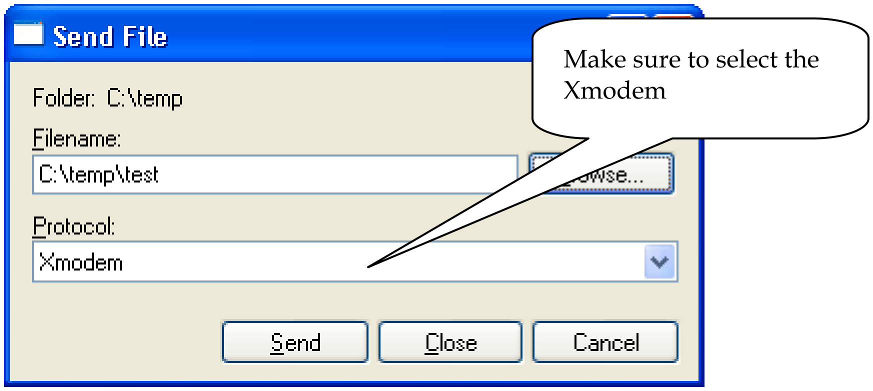
2-2 Restore Settings

OK > sus 99

OK > wus

X-Modem Transfer from Host.

Click **Send file…** in the Transfer menu to load a settings.



3. Transfer FPN & PRNU Coefficients

3-1 Save FPN & PRNU Coefficients

OK> sfs 99

OK > lpc

X-Modem Transfer to Host. Camera is ready for sending...

Click **Receive file…** in the Transfer menu to save a settings.

3-2 Restore FPN & PRNU Coefficients

OK > sfs 99

OK > wpc

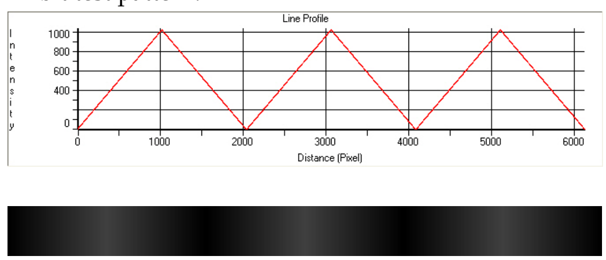
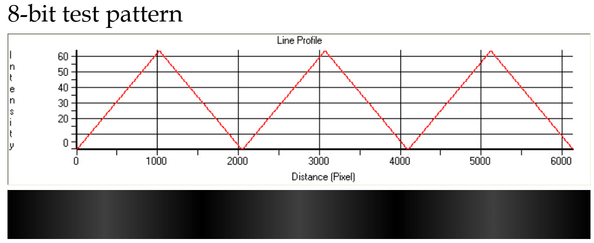
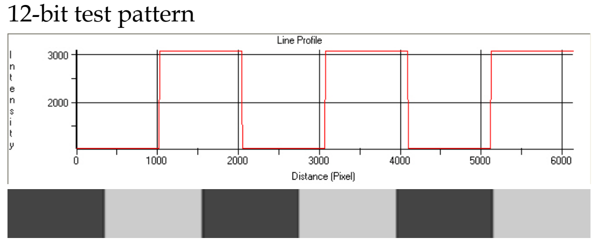
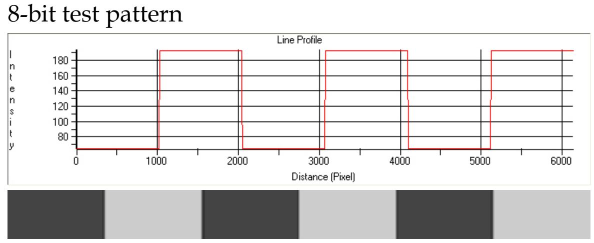
X-Modem Transfer from Host.

Click **Send file…** in the Transfer menu to load a settings.

OK>

4.12 Test Patterns

Generating a Test Pattern

Purpose:	Generates a test pattern to aid in system debugging. The test patterns are useful for verifying camera timing and connections. The following tables show each available test pattern.	
Syntax:	**`svm`** ***`i`***	
Syntax Elements:	***`i`***	
svm	**`0`**	Video. Raw.
svm	**`1`**	12-bit test pattern. 
svm	**`1`**	8-bit test pattern 
svm	**`2`**	12-bit test pattern 
svm	**`2`**	8-bit test pattern 
Related Commands	**`smm`**	Use the set mirror mode (smm) command to establish the direction of the pixel readout.

4.13 Returning Video Information

The camera's microcontroller has the ability to read video data. This functionality can be used to verify camera operation and to perform basic testing without having to connect the camera to a frame grabber. This information is also used for collecting line statistics for calibrating the camera.

Returning a Single Line of Video

Purpose:	Returns a complete line of video (without pixel coefficients applied) displaying one pixel value after another. After pixel values have been displayed it also displays the minimum, maximum, and mean value of the line sampled within the region of interest (the region of interest command is explained in section Setting a Region of Interest (ROI)). Use the **`gl`** command, or the following **`gla`** command, to ensure the proper video input range into the processing chain before executing any pixel calibration commands.
Syntax:	**`gl`**
Notes:	• Range defined using the **spx** and **spw** commands. • Default settings: **spx 1** and **spw 2**. • Values returned are in 12-bit DN.
Related Commands	**`spw, spx`**
Example:	**`gl`**

Returning Averaged Lines of Video

Setting the Number of Lines to Sample

Purpose:	Sets the number of lines to sample when using the **`gla`** command or when performing FPN and PRNU calibration.
Syntax:	**`css`** ***`m`***
Syntax Elements:	**`m`** Number of lines to sample. Allowable values are **`256`**, **`512`**, or **`1024`** (factory setting).
Notes:	• To return the current setting, use the **`gcp`** command or **`get css`**.
Related Commands:	**`gla, ccf, cpa`**
Example:	**`css 1024`**

Returning the Average of Multiple Lines of Video

Purpose:	Returns the average for multiple lines of video data (without pixel coefficients applied). The number of lines to sample is set and adjusted by the **`css`** command. The camera displays the Min., Max., and Mean statistics for the pixels in the region of interest (the region of interest command is explained in section Setting a Region of Interest (ROI)).
Syntax:	**`gla`**
Notes:	• Range defined using the **spx** and **spw** commands. • Analog gain, analog offset, digital offset, background subtract, and digital system gain are applied to the data. FPN and PRNU coefficients are not included in the data. • Values returned are in 12 bit DN.
Related Commands:	**`spw, spx`**
Example:	**`gla`**

4.14 Temperature Measurement

The temperature of the camera can be determined by using the **`vt`** command. This command will return the internal chip case temperature in degrees Celsius. For proper operation, this value should not exceed 75°C.

Note: If the camera reaches 75°C, the camera will shutdown and the LED will flash red. If this occurs, the camera must be rebooted using the command, **`rc`** or can be powered down manually. You will not be able to restart the camera until the temperature is less than 65°C. You will have to correct the temperature problem or the camera will shutdown again. The camera allows you to send the **`vt`** (verify temperature) command while it is in this state.

4.15 Voltage Measurement

The command **`vv`** displays the camera's input voltage. Note that the voltage measurement feature of the camera provides only approximate results (typically within 10%). The measurement should not be used to set the applied voltage to the camera but only used as a test to isolate gross problems with the supply voltage.

4.16 Camera Frequency Measurement

Purpose:	Returns the frequency for the requested Camera Link control signal
Syntax:	**gsf *i***
Syntax Elements:	***i*** Camera Link control signal to measure: **1**: CC1 (EXSYNC) **2**: CC2 (PRIN) **3**: CC3 (CCD Direction)
Note:	• Camera operation may be impacted when entering the gsf command (i.e., poor time response to direction change or video may have artifacts (gain changes) for several lines while the camera returns signal information) • This command is not available when operating the camera with external CCD direction control (**scd 2**)
Example:	**gsf 1**

4.17 Returning the LED Status

Purpose:	Returns the status of the camera's LED.
Syntax:	**gsl** The camera returns one of the following values: **1** = red (loss of functionality) **2** = green (camera is operating correctly) **5** = flashing green (camera is performing a function) **6** = flashing red (fatal error)
Notes:	• Refer to section 2.4 Camera LED for more information on the camera LED

4.18 Returning Camera Settings

Returning All Camera Settings with the Camera Parameter Screen

The camera parameter (gcp) screen returns all of the camera's current settings. The table below lists all of the gcp screen settings.

To read all current camera settings, use the command: gcp

GCP Screen		
GENERAL CAMERA SETTINGS		
Camera Model No.:	**SC-30-0xK80-00-R**	Camera model number

Camera Serial No.:	**xxxxxxxx**	Camera serial number
Firmware Version:	**xx-xxx-xxxxx-xx**	Firmware design revision number
CCI Version:	**xx-xxx-xxxxx-xx**	CCI version number
FPGA Version:	**xx-xxx-xxxxx-xx**	FPGA revision number
Set Number:	**1**	Last user set loaded, set with sus command
UART Baud Rate:	**9600**	Serial communication connection speed set with the sbr command
Camera Link Mode:	**clm:2 (2 taps, 8 bits)**	Current bit depth setting set with the clm command
Mirroring Mode:	**0, left to right**	Tap readout direction: left to right, or right to left. Set with the smm command
Readout Mode:	**Off**	Current readout mode status. Set using the srm command
Exposure Mode:	**7**	Current exposure mode value set with the sem command
SYNC Frequency:	**1600.00 Hz**	Current line rate. Value is set with the ssf command
Exposure Time:	**200.00 uSec**	Current exposure time setting. Value is set with the set command
CCD Direction:	**internal/forward**	Current direction setting set with scd command
Video Mode:	**video**	Current video mode value set with the svm command
Region Of Interest X:	**1**	The starting horizontal position of Region Of Interest. Set with srx command
Region Of Interest Width:	**2048 or 4096**	Width of Region Of Interest in pixel. Set with srw command
End-Of-Line Sequence:	**off**	States whether an end of line sequence is turned on or off. Set using the els command
FFC Coefficient Set:	**1**	Current pixel coefficient set loaded, set with sfs command
FPN Coefficients:	**on**	States whether FPN coefficients are on or off. Set with the epc command
PRNU Coefficients:	**on**	States whether PRNU coefficients are on or off. Set with the epc command.
Input LUT:	**off**	States whether LUT correction is on or off. Set with eil command
Input LUT Coefficients Set:	**0**	Current LUT coefficient set loaded, set with sis command
Number Of Line Samples:	**1024**	Number of lines samples set with the css command
Upper Threshold:	**3600**	Upper threshold value set with the sut command
Lower Threshold:	**400**	Lower threshold value set with the slt command
Current Tap:	**0**	Current tap, set with sct command
Colour:	**RGB**	Current color, set with scl command
Current Light:	**unadjusted**	Current light source, set with sls command

Color Gain(dB):	`Red 7.36 7.48`	Current color gain, set with scl, sct, scg commands
	`Green 17.23 17.37`	
	`Blue 18.56 21.19`	
Color Reference(dB):	`Red 0.00 0.00`	Current color reference level, update with ucr command
	`Green 0.00 0.00`	
	`Blue 0.00 0.00`	
Total Color Gain(dB):	`Red 7.36 7.48`	Total color gain in DB, read only value
	`Green 17.23 17.37`	
	`Blue 18.56 21.19`	
Total Color Gain(DN):	`Red 9563 9689`	Total color gain in DN, read only value
	`Green 29778 30276`	
	`Blue 34704 46988`	
Color Correction:	`O r g b`	Color correction matrix, set with scx, scy and scc commands.
	`r 0 4096 0 0`	
	`g 0 0 4096 0`	
	`b 0 0 0 4096`	
	`y 0 0 0 0`	
Black Level Offset:	`12 11`	Current amount of black level correction
Background Subtract:	`0`	Background subtract settings set with the ssb command
System Gain (DN):	`4096`	Digital gain settings set with the ssg command

Returning Camera Settings with Get Commands

You can also return individual camera settings by inserting a "**`get`**" in front of the command that you want to query. If the command has a tap or pixel number parameter, you must also insert the tap number or pixel number that you want to query. To view a help screen listing the get commands, use the command **`gh`**.

4.19 ASCII Commands: Reference

The following table lists all of the camera's available ASCII commands. Refer to Appendix A for detailed information on using these ASCII commands.

Parameters:
t = tap id
i = integer value
f = float
m = member of a set
s = string
x = pixel column number
y = pixel row number

Table 14: Command Quick Reference

Mnemonic	Syntax	Parameters	Description
Help, single command	**?**	**s**	Returns help on a single command
correction calibrate fpn	**ccf**		Performs FPN calibration and eliminates FPN noise by subtracting away individual pixel dark current
Camera Link mode	**clm**	**i**	Sets the camera's bit width where: **0** = GREEN, 8 bits, 1 tap **1** = GREEN, 12 bits, 1 tap **2** = Mono, 8 bits, 2 taps **3** = Mono, 12 bits, 2 taps **5** = RGB, 8 bit, 3 taps **6** = RGB, 12 bits, 3 taps **9** = RGBY, 8 bits, 4 taps **10** = RGBY, 12 bits, 4 taps
calculate PRNU algorithm	**cpa**	**i i**	Performs PRNU calibration according to the selected algorithm. The parameter is the target value to use in a range from **1024** to **4055** DN. $\text{PRNU Coefficient}_i = \frac{\text{Target}}{(\text{AVG Pixel Value}_i)}$ The calculation is performed for all sensor pixels but warnings are only applied to pixels in the region of interest. This algorithm is useful for achieving uniform output across multiple cameras.
correction set sample	**css**	**m**	Sets the number of lines to sample when using the gla command or when performing FPN and PRNU calibration where **m** is **256**, **512**, or **1024**
calibrate white balancing	**cwb**	**i**	Adjust color digital gain to make the color output to the given value while imaging a white reference
display pixel coeffs	**dpc**		Displays the pixel coefficients in the order FPN, PRNU, FPN, PRNU, …
enable FPN coeffs	**efc**	**i**	Sets whether FNU coefficients are enabled or disabled. Where **i** is: **0** = FPN coefficients disabled **1** = FPN coefficients enabled
enable input LUT	**eil**	**i**	Enable input LUT, where: **0**: Off **1**: On

Mnemonic	Syntax	Parameters	Description
end of line sequence	**els**	**i**	Sets the end-of-line sequence: **0**: Off **3**: LVAL extended by 16 (stat) pixels 7: LVAL shifted by 16 pixels to encompass stat pixels
enable PRNU coefficients	**epc**	**i**	Sets whether PRNU coefficients are enabled or disabled. Where **i** is: **0** = PRNU coefficients disabled **1** = PRNU coefficients enabled
get command log	**gcl**		Returns list of commands sent.
get camera model	**gcm**		Reads the camera model number.
get camera parameters	**gcp**		Reads all of the camera parameters.
get camera serial	**gcs**		Read the camera serial number.
get camera version	**gcv**		Read the firmware version and FPGA version.
get value	**get**	**s**	Returns the value of the parameter specified.
get help	**gh**		Returns all of the available "get" commands.
get line	**gl**		Gets a line of video (without pixel coefficients applied) displaying one pixel value after another and the minimum, maximum, and mean value of the sampled line.
get line average	**gla**		Read the average of line samples.
get signal frequency	**gsf**	**i**	Reads the requested Camera Link control frequency. **1** = EXSYNC frequency **2** = Spare **3** = Direction
get status led	**gsl**		Returns the current state of the camera's LED where: **1** = Red **2** = Green **5** = Blinking green **6** = Blinking red
Help	**h**		Display the online help. Refer to the Select Cable Camera ASCII Command Help for details.
load pixel coefficients	**lpc**		Loads the previously saved pixel coefficients from non-volatile memory
Load user settings	**lus**		Load the settings saved using the **lus** command at set specified in **sus** command
reset camera	**rc**		Resets the entire camera (reboot). Baud rate is not reset and reboots with the value last used.

Mnemonic	Syntax	Parameters	Description
reset pixel coeffs	`rpc`		Resets the pixel coefficients to 0.
set baud rate	`sbr`	`i`	Set the speed of camera serial communication port. Baud rates: **`9600`**, **`19200`**, **`57600`**, and **`115200`**. Default: 9600.
set color correction	`scc`	`i`	Set the values in the color matrix that is multiplied at the end of the digital processing.
set ccd direction	`scd`	`i`	Sets the CCD shift direction where: **`0 =`** Forward CCD shift direction. **`1 =`** Reverse CCD shift direction. **`2 =`** Externally controlled direction control via CC3. (CC3=1 forward, CC3=0 reverse.)
set color gain	`scg`	`i`	Set color gain for current color in a range of **0 to 65535**. The current color is set from **scl** command.
set color selector	`scl`	`m`	Selects color for gain application. Used prior to the **scg** command
Set current tap	sct	`t`	Selects tap for color gain application. Used prior to the **scg** command.
set color correction matrix X index	`scx`	`m`	Set current color correction x index in a range of **o/r/g/b**.
set color correction matrix Y index	`scy`	`m`	Set current color correction y index in a range of **r/g/b/y**.
Set exposure control	sec	`m`	This command combines slm command are equivalent to sem command. Set exposure control mode. If input is t, this mode uses the value set by the “set” command for the exposure time If input is w, this mode uses the width of the line trigger pulse. If the user tries to set this mode while “slm” is set to internal, then they will receive an error: not available in this mode. If the user sets the “slm’ to internal while the “sec” value is set to width. The camera will return a warning message and change the exposure control to maximum. If input I is m. The camera uses the maximum possible exposure time for the given line rate.

Mnemonic	Syntax	Parameters	Description
set exposure mode	**sem**	**m**	Sets the exposure mode: **2 =** Internal SYNC, internal PRIN, programmable line rate and exposure time using commands **ssf** and **set** **3 =** External SYNC, internal PRIN, maximum exposure time **4** = Smart EXSYNC **6** = External SYNC, internal PRIN, programmable exposure time **7 =** Internal programmable SYNC, maximum exposure time. Factory setting. **8** = Internal SYNC, internal PRIN, programmable exposure time. Maximum line rate for exposure time.
set exposure time	**set**	**f**	Sets the exposure time. Refer to the camera help screen (**h** command) for allowable range.
set FFC set number	**sfs**	**i**	Set to load/save using the **lpc**, **wpc**, **wfc** commands.
set input [lut] selector	**sis**	**m**	Set the input lut set used in the wil commands.
set line mode	**slm**	**m**	Set the line trigger mode as either external or internal: e—external line trigger i—internal line trigger.
set light source	**sls**	**i**	Set current light source in a range of **0 to 5**.
set lower threshold	**slt**	**i**	The pixels below the lower threshold are checked for and reported in the end-of-line sequence in a range from **0-4095**.
set mirroring mode	**smm**	**i**	Set tap readout direction: left to right, or right to left
set pixel window width	**spw**	**i**	Set horizontal width used in gl, gla, dpc commands.
set pixel X position	**spx**	**i**	Set horizontal starting position used in gl, gla, dpc commands.
set readout mode	**srm**	**i**	Set the readout mode in order to clear out dark current charge in the vertical transfer gates before the sensor is read out. **0** = Auto. **1** = Dark current clear. **2** = Immediate readout. Does not clear dark current.
set ROI width	**srw**	**i**	Specify the width of the ROI.
set ROI X	**srx**	**i**	Specify the starting X position of the ROI.
set subtract background	**ssb**	**i**	Subtract the input value from the output signal. **i** = Subtracted value in a range from **0** to **4095**.

Mnemonic	Syntax	Parameters	Description
set sync frequency	`ssf`	`i`	Set the frame rate to a value from **`300`** Hz to **`18000`** Hz (2k model). Value rounded up/down as required.
set system gain	`ssg`	`i`	Set the digital gain. **`i`** = Digital gain in a range from **`0`** to **`65535`**. The digital video values are multiplied by this number.
set user set number	`sus`	`i`	
set upper threshold	`sut`	`i`	The pixels equal to or greater than the upper threshold are checked for and reported in the end-of-line sequence in a range from **`0-4095`**.
set video mode	`svm`	`i`	Switch between normal video mode and camera test patterns: **`0`**: Normal video mode **`1`**: Camera test pattern **`2`**: Camera test pattern
Update color reference	`ucr`		Set the color reference value to the current color gain value.
verify temperature	`vt`		Check the internal temperature of the camera.
verify voltage	`vv`		Check the camera's input voltages and return OK or fail.
write FPN coefficients	`wfc`		Write all current FPN coefficients to non-volatile memory.
write input LUT	`wil`		Write current LUT's to non-volatile memory.
write PRNU coeffs	`wpc`		Write all current PRNU coefficients to non-volatile memory.
write user settings	`wus`		Write all of the user settings to non-volatile memory.

4.20 Error Handling

The following table lists warning and error messages and provides a description and possible cause. Warning messages are returned when the camera cannot meet the full value of the request; error messages are returned when the camera is unable to complete the request.

Table 15: Warning and Error Messages

Message	Description
OK>	SUCCESS
Warning 01: Outside of specification>	Parameter accepted was outside of specified operating range (e.g. gain greater than 0 to +20 dB of factory setting).

Message	Description
Warning 02: Clipped to min>	Parameter was clipped to the current operating range. Use **gcp** to see value used.
Warning 03: Clipped to max>	Parameter was clipped to the current operating range. Use **gcp** to see value used.
Warning 04: Related parameters adjusted>	Parameter was clipped to the current operating range. Use **gcp** to see value used.
Warning 07: Coefficient may be inaccurate A/D clipping has occurred>	In the region of interest (ROI) greater than 6.251% single or 1% of averaged pixel values were zero or saturated.
Warning 08: Greater than 1% of coefficients have been clipped>	A FPN/PRNU has been calculated to be greater than the maximum allowable 511 (8).
Warning 09: Internal line rate inconsistent with readout time>	

Message	Description
Error 02: Unrecognized command>	Command is not available in the current access level or it is not a valid command.
Error 03: Incorrect number of parameters>	
Error 04: Incorrect parameter value>	This response returned for · Alpha received for numeric or vice versa · Not an element of the set of possible values. E.g., Baud Rate · Outside the range limit
Error 05: Command unavailable in this mode>	Command is valid at this level of access, but not effective. Eg line rate when in smart Exsync mode
Error 06: Timeout>	Command not completed in time. Eg FPN/PRNU calculation when no external Exsync is present.
Error 07: Camera settings not saved>	Tried saving camera settings (**rfs**/**rus**) but they cannot be saved.
Error 08: Unable to calibrate - tap outside ROI>	Cannot calibrate a tap that is not part of the region of interest.
Error 09: The camera's temperature exceeds the specified operating range>	Indicates that the camera has shut itself down to prevent damage from further overheating.

4.21 Clearing Dark Current

Gate Dark Current Clear

Image sensors accumulate dark current while they wait for a trigger signal. If the readout is not triggered in a reasonable amount of time, then this dark current accumulation may increase to an excessive amount. The result of this happening will be that the first row, and possibly additional rows (frames), of the image will be corrupt.

The sensor used in this camera contains two sources of dark current that will accumulate with time: 1) in the photo sensitive area, and 2) in the gates used to clock-out the charge.

The gate dark current can account for approximately 20% of the total dark current present. While the exposure control has direct control over the amount of dark current in the photo sensitive area, it has no control over the charge accumulated in the gates. Even with exposure control on, at low line rates, this gate charge can cause the camera to saturate.

Using the **`Set Readout Mode (srm)`** command, the camera user can control the camera's behavior in order to minimize the dark current artifact.

The modes of operation selected by the **`srm`** command are: Auto, On, or Off.

Figure 20: Gate Dark Current Clear

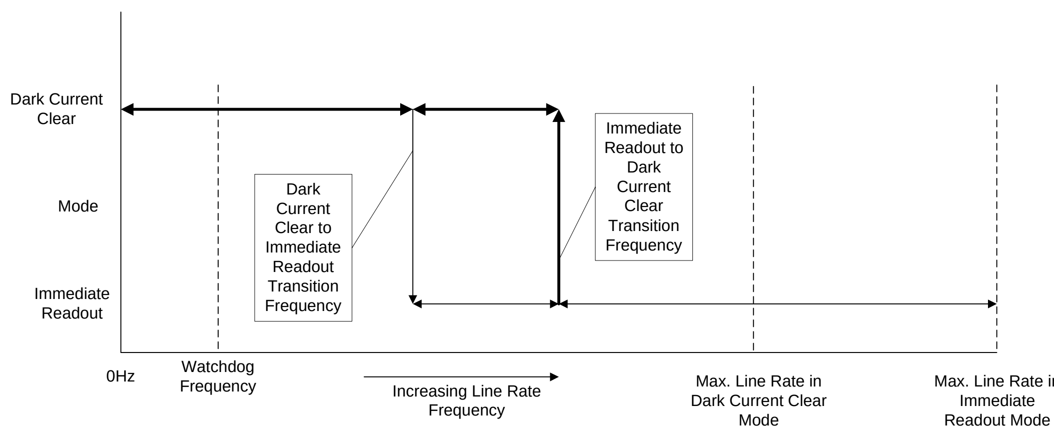


Table 16. Transition Frequencies

Model	Dark Current Clear to Immediate Readout Transition	Immediate Readout to Dark Current Clear Transition
SC-30-02k80	6767 Hz	8176 Hz
SC-30-04k80	3518 Hz	4257 Hz

Immediate read out mode (srm 2)

In this mode the image is read out, including accumulated dark current, immediately following the trigger or the EXSYNC falling edge.

There are no line rate limitations other than the amount of gate dark current that can be tolerated at low line rates.

There are no timing or exposure anomalies other than situations where EXSYNC is removed from camera. In this case, the camera will operate in a "watchdog" state.

For information on artifacts that may be experienced while using this mode, see the Artifacts section below.

Gate dark current clear mode (always on, srm 1)

In this mode the gate dark current will be cleared continuously.

After the trigger (EXSYNC) is received, the dark current is cleared from the image sensor before the image is acquired. The line rate is limited to ½ the maximum line rate available for that model of camera.

For information on artifacts that may be experienced while using this mode, see the Artifacts section below.

Table 17. Maximum Line Rates

	Max. Line Rate	
Model	**Immediate Readout Mode**	**Dark Current Clear Mode**
SC-30-02k80	18000 Hz	9000 Hz
SC-30-04k80	9000 Hz	4500 Hz

When operating in the dark current clear mode, there will be a slight delay, equivalent to one readout time, before the actual exposure is implemented. The actual exposure time will not be altered.

Table 18. Exposure Delay and Maximum Exposure Time in Auto Mode

Model	Exposure Delay and Max Exposure Time in Auto Mode
SC-30-02k80	55.5 µs
SC-30-04k80	111 µs

Auto Mode (default, srm 0)

In this mode the line rate from the camera will automatically cause a switch between the gate dark current clear mode and non gate dark current clear mode.

The frequency of when this mode switchover occurs depends on the camera model.

In cases where the line rate is rapidly increased from below the Dark Current Clear to Immediate Readout Transition Frequency to above the Immediate Readout to Dark Current Clear Transition Frequency, the first line following this transition will likely be corrupted.

The table below outlines the artifacts that may be seen during this transition period. All subsequent lines after this occurrence will be as expected.

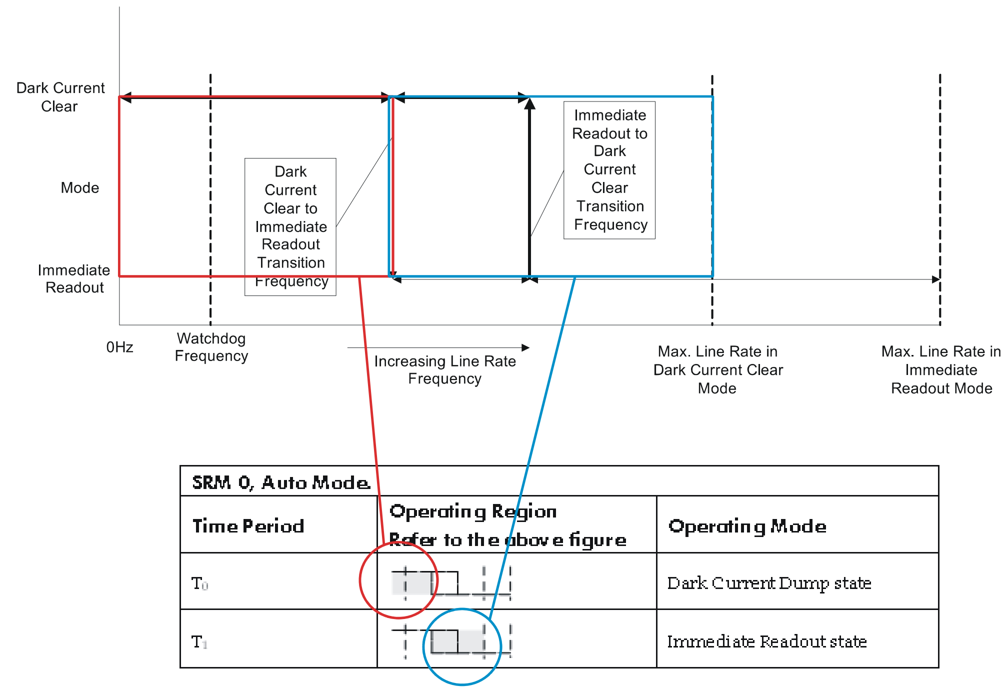
In the case of a slow transition (that is, when the EXSYNC line rate increases by less than 10% of the previous line rate) a line readout will not become corrupt.

There are also limitations on the exposure time when operating in auto mode: If the line rate exceeds half the maximum line rate, then the exposure time cannot exceed the time stated in Table 18.

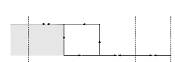
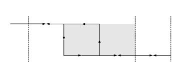
Note: DALSA recommends Auto mode for most users.

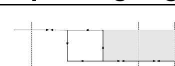
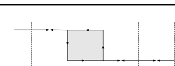
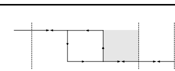
For information on artifacts that may be experienced while using this mode, see the Artifacts section below.

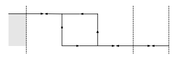
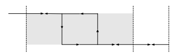
Please note: The graphic below explains the relationship between the following tables and the preceding figure, Gate Dark Current Clear.



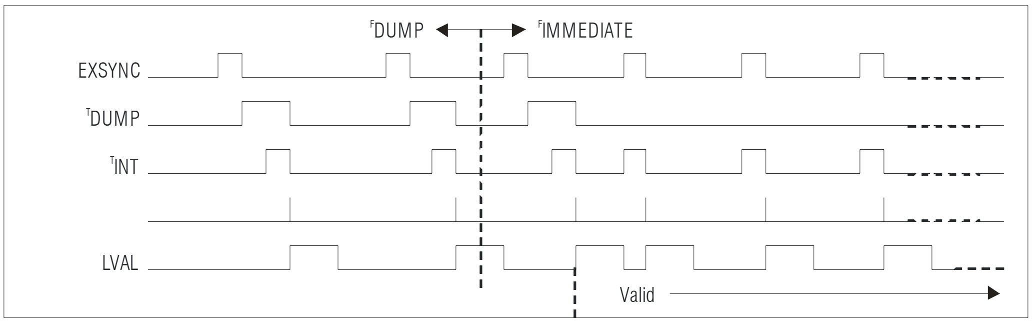
Dark Current Dump to Immediate Readout: Multi-Line Artifacts.

SRM 0, Auto Mode.		
Time Period	**Operating Region**	**Operating Mode**
T_0		Dark Current Dump state
T_1		Immediate Readout state

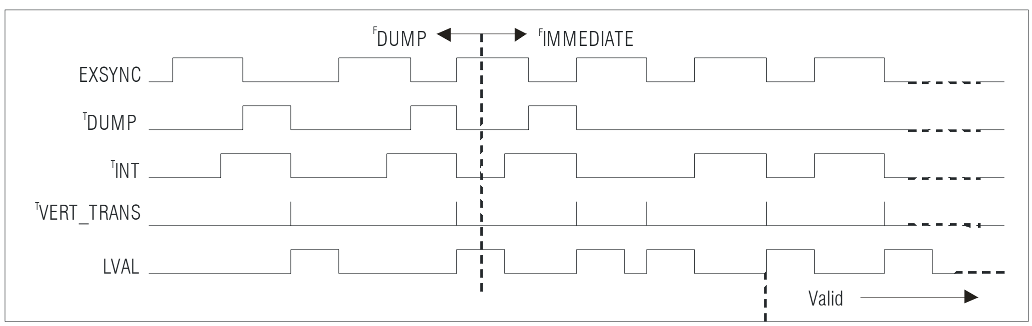
SRM 0, Auto Mode.		
Time Period	**Operating Region**	**Operating Mode**
T_0		Immediate Readout state
T_1		Dark Current Dump state
T_2		Immediate Readout state

SRM 2, Immediate Readout Mode.		
Time Period	**Operating Region**	**Operating Mode**
T_0		Dark Current Dump state
T_1		Immediate Readout state

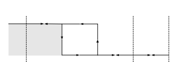
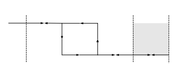
Dark Current Dump to Immediate Readout (T_{INT} < #)

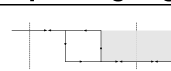


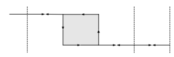
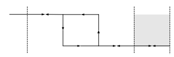
Dark Current Dump to Immediate Readout (T_{INT} > #)

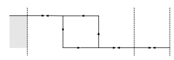
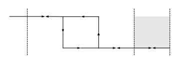


Dark Current Dump to Immediate Readout: Multi-Line Artifacts

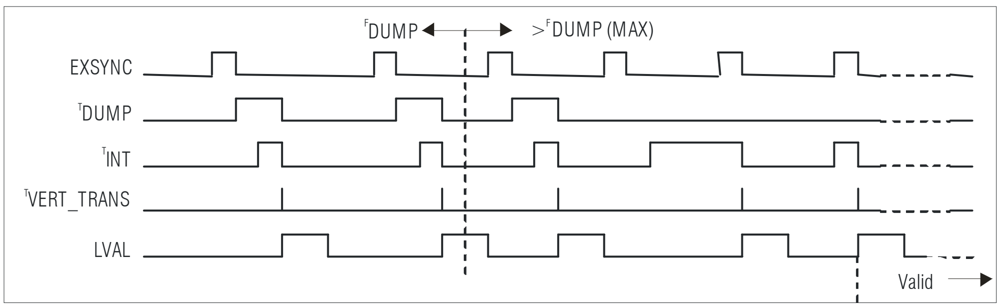
SRM 0, Auto Mode.		
Time Period	**Operating Region**	**Operating Mode**
T_0		Dark Current Dump state
T_1		Immediate Readout state

SRM 0, Auto Mode.		
Time Period	**Operating Region**	**Operating Mode**
T_0		Immediate Readout state

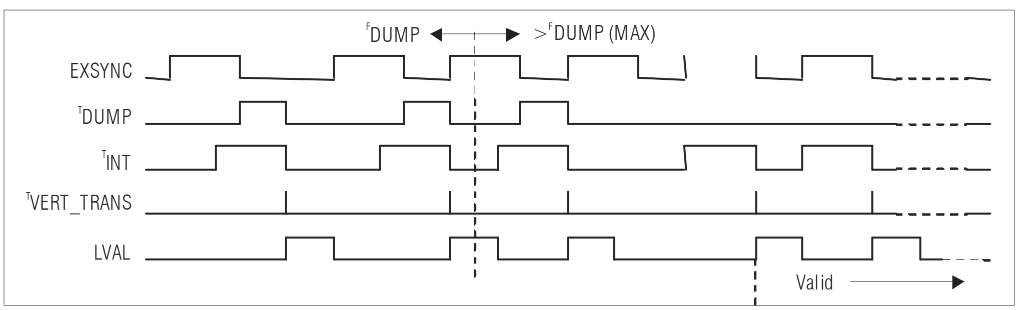
T_1		Dark Current Dump state
T_2		Immediate Readout state

SRM 2, Immediate Readout Mode.		
Time Period	**Operating Region**	**Operating Mode**
T_0		Dark Current Dump state
T_1		Immediate Readout state

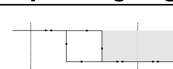
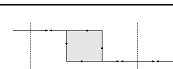
Dark Current Dump to Immediate Readout (T_{INT} < #)

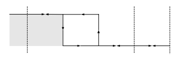
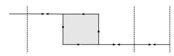
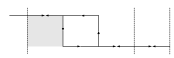


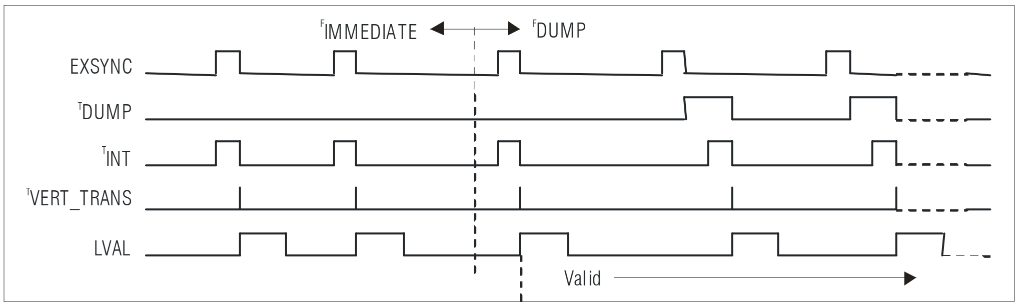
Dark Current Dump to Immediate Readout (T_{INT} > #)



Immediate Readout to Dark Current Dump: Hysteresis Artifacts

SRM 0, Auto Mode.		
Time Period	**Operating Region**	**Operating Mode**
T_0		Immediate Readout state
T_1		Dark Current Dump state

SRM 0, Auto Mode.		
Time Period	**Operating Region**	**Operating Mode**
T_0		Dark Current Dump state
T_1		Immediate Readout state
T_2		Dark Current Dump state



Setting the Readout Mode

Purpose: Use this command to clear out dark current charge in the vertical transfer gates immediately before the sensor is read out.

Syntax: **srm**

Syntax Elements: **i**

0: Auto. Clears dark current below ~ 45% of the maximum line rate. (Default mode.)

1: Dark current clear. Always clears dark. Reduces the maximum line rate.

2: Immediate readout. Does not clear dark current.

Notes:

- Modes 0 and 1 are not available to the 4k camera model.
- The vertical transfer gates collect dark current during the line period. This collected current is added to the pixel charge. The middle two red taps have more vertical transfer gates and, therefore, more charge. This additional charge is especially noticeable at slower line rates.
- If the user is in **sem 2** or **7** and **srm 2**, with **ssf** at 45% of the maximum, and then srm 1 is selected, the following warning will be displayed, but the ssf value will not be changed: Warning 09: Internal line rate inconsistent with readout time> The effect in both internal and external line rate modes is that an EXSYNC is skipped and, therefore, the output will be at least twice as bright.
- This value is saved with the camera settings.
- This value may be viewed using either the **gcp** command or the get **srm** command.

Related Commands: **sem, ssf**

Example: **srm 0**

5 DCT GUI Interface

You can interact with the camera either through the ASCII command interface or through the DCT GUI. Either option gives you extensive control over the camera.

The GUI is explained here. For a description of the ASCII interface, see the Software Interface section, page 25.

System requirements and software installation

The readme.txt that comes with the installation package describes the system requirements, software installation steps, and software components installed.

5.1 Getting Help

The application provides searchable help file describing the GUI windows, providing descriptions of specific features as well as conceptual information related to those features.

You can find help from the accompanying user guide or directly from the GUI Help.

5.2 Operating Tips

In case that parameter window is empty:

- Check if the frame grabber serial port is mapped.
- Check if the hyper terminal and/or DALSA terminal is open. If so, close them first and then reopen the GUI.
- Check if the camera power is on.

Use the hyper terminal or DALSA terminal to diagnose if there are issues with the camera. Use DALSA CamExpert or a third party frame grabber tool to diagnose if there are issues with the frame grabber. If there are no issues with either the camera or the frame grabber, then close those applications, and re-open the GUI.

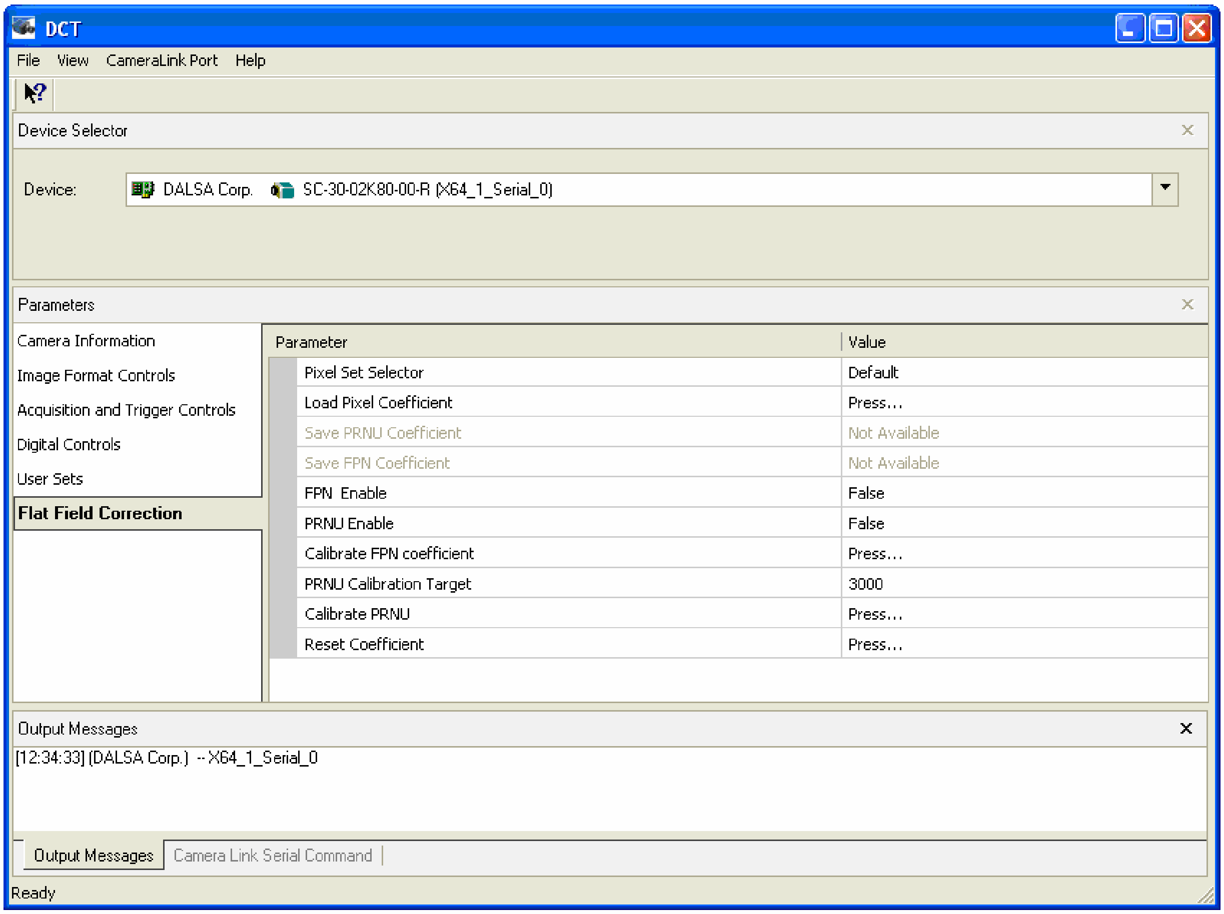
Camera should always operate in user mode.

On start-up, DCT will automatically connect to a camera. If the connection is successful, all parameters are retrieved from the camera and displayed in the parameter window. Otherwise the parameter window will be empty. DCT can detect a camera manually using the DALSA Camera Detection menu item under the CameraLink Port menu. DCT will not automatically detect the loss of a connection due to a power loss or a loose cable.

5.3 GUI Window

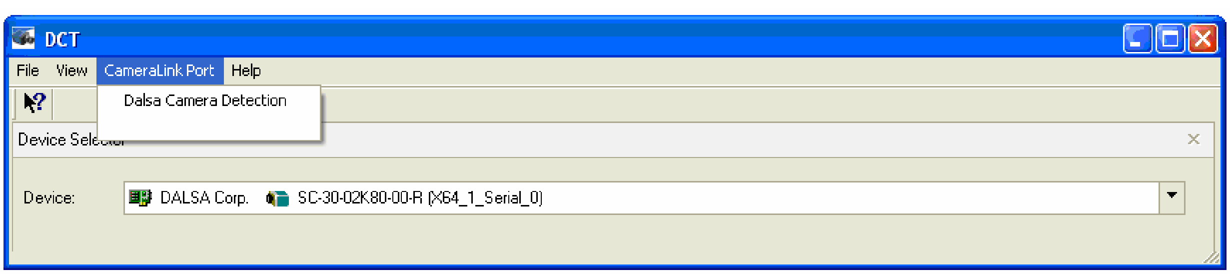
Figure 21: Main GUI Window

From the main DCT GUI window, select from the Parameters list to access the camera features.



5.4 Detecting Cameras

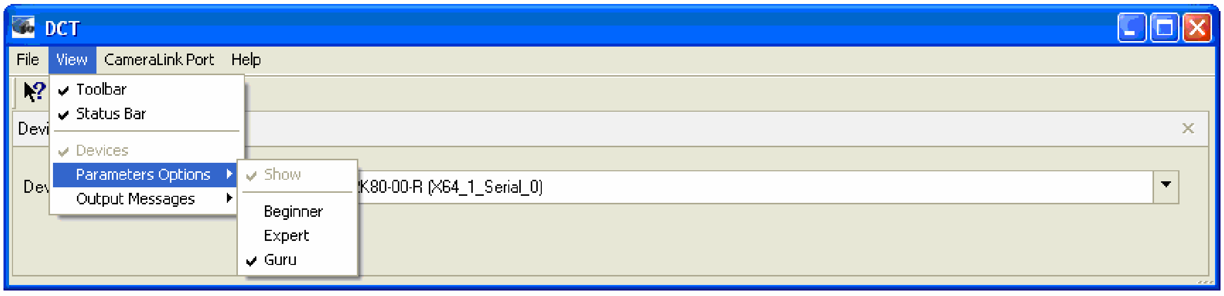
Figure 22: Camera Detect



To manually detect a camera, under the CameraLink Port menu, click Dalsa Camera Detect.

5.5 User Levels

Figure 23: User Levels

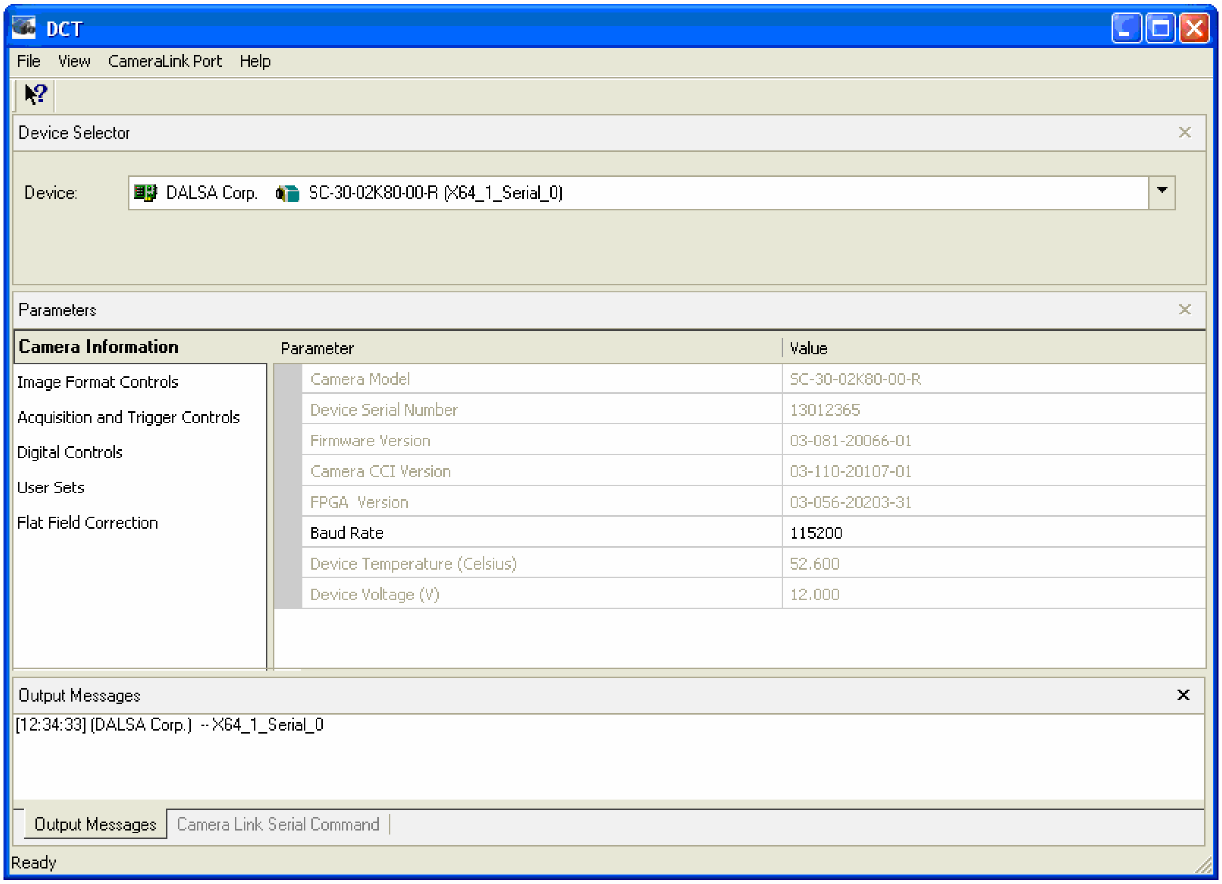


The features in the GUI parameter windows are grouped into the following user levels: Beginner, Expert, Guru.

By selecting Beginner from the menu View > Parameters Options, only parameters belonging to the beginner level will be displayed in parameter windows. However, when selecting the higher levels (Expert and Guru), parameters below these levels will also be included. At the GURU level all parameters are displayed to the user.

5.6 Camera Parameters

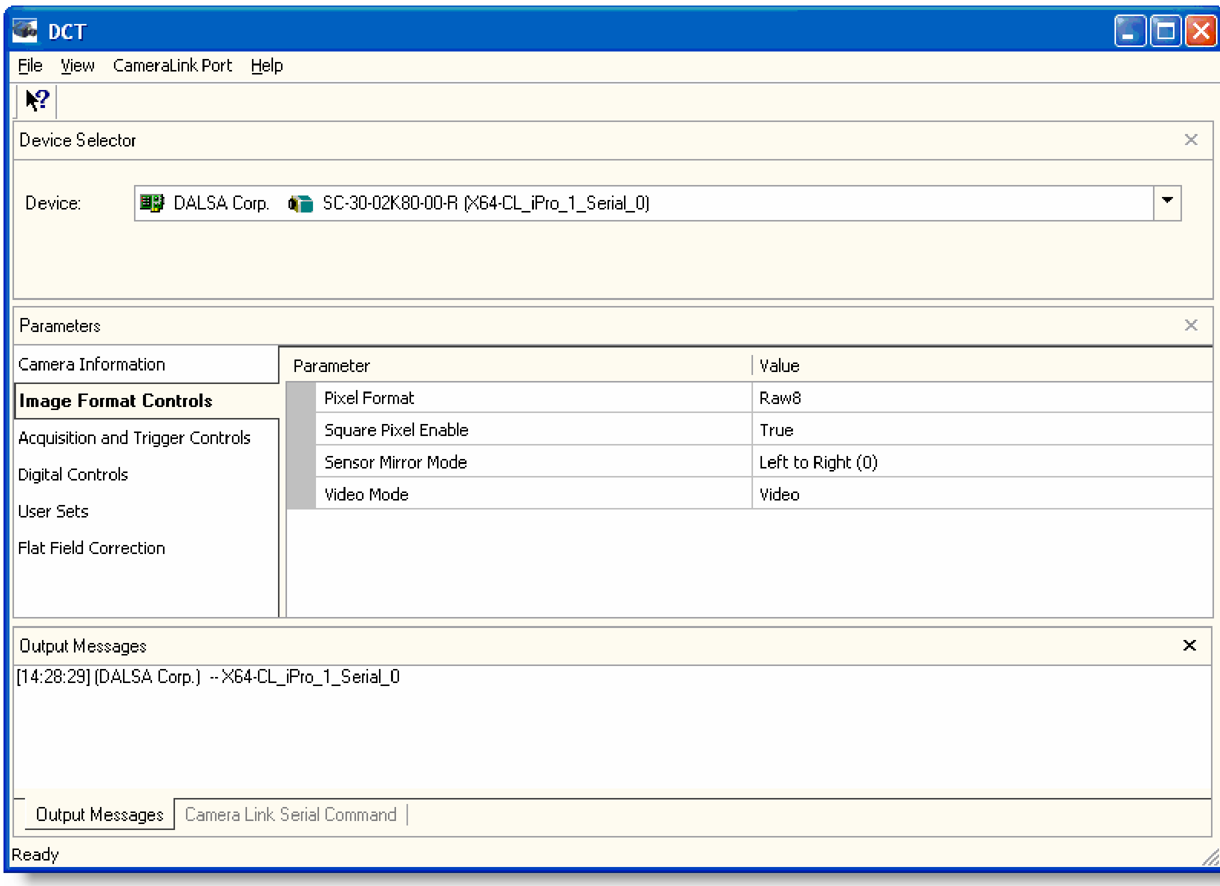
Figure 24: Camera Information



Name	Visibility	Description	ASCII Command	Command Range	Additional Information
Camera Model	Beginner	Camera model name.	gcm	NA	NA
Device Serial Number	Beginner	A unique identifier of the camera. This number matches the serial number on the camera's label.	gcs	NA	NA
Firmware version	Beginner	Firmware version.	gcv	NA	NA
Camera CCI version	Beginner	Camera CCI (Camera Configuration Information) version.	gcv	NA	NA
FPGA version	Beginner	FPGA version.	gcv	NA	NA
Baud Rate	Beginner	Camera Baud Rate. The DCT automatically changes the camera's baud rate to 115200. The Baud rate is switched back to the	sbr	9600/19200/ 57600/115200	Baud Rate, page 26.

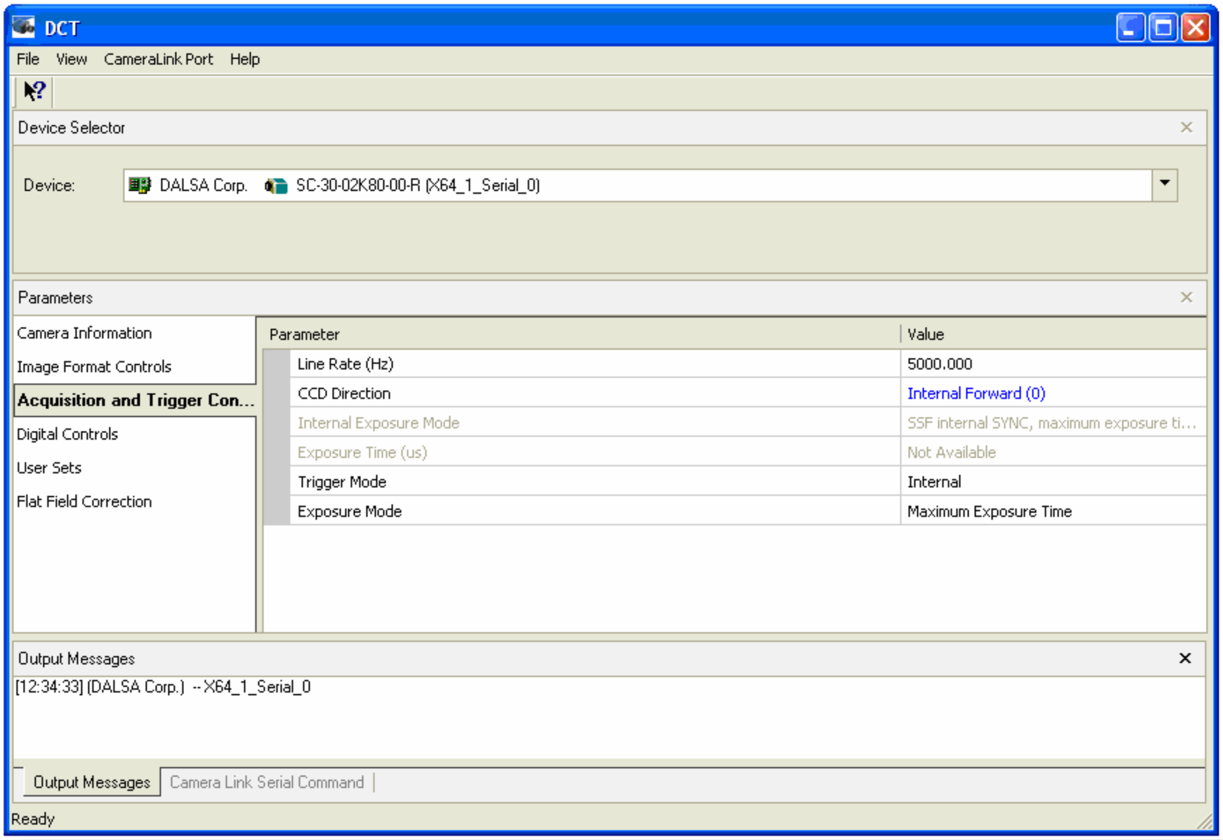
		previous setting after closing DCT.			
Device Temperature	Beginner	The camera's temperature, in Celsius.	vt	NA	NA
Device Voltage	Beginner	The camera's DC voltage (V).	vv	NA	NA

Figure 25: Image Format Control



Name	Visibility	Description	ASCII Command	Command Range	Additional Information
Pixel Format	Beginner	Format of the image pixels.	clm	raw8, raw12, rgb8, rgb12, rgba8, rgba12	Setting the Camera Link Mode, page 31.
Enable Line Delay	Guru	Enables the line delay.	eld	True, False	Enabling Line Delay, page 38.
Sensor Mirror Mode	Expert	Controls the horizontal direction of the image.	smm	Left to Right (0), Right to Left (1)	Setting the Pixel Readout Direction, page 36.
Video Mode	Guru	Video mode. Raw is real image. Ramp and Fixed data are built-in test patterns.	svm	Video, ramp, fixed data	Generating a Test Pattern, page 58.

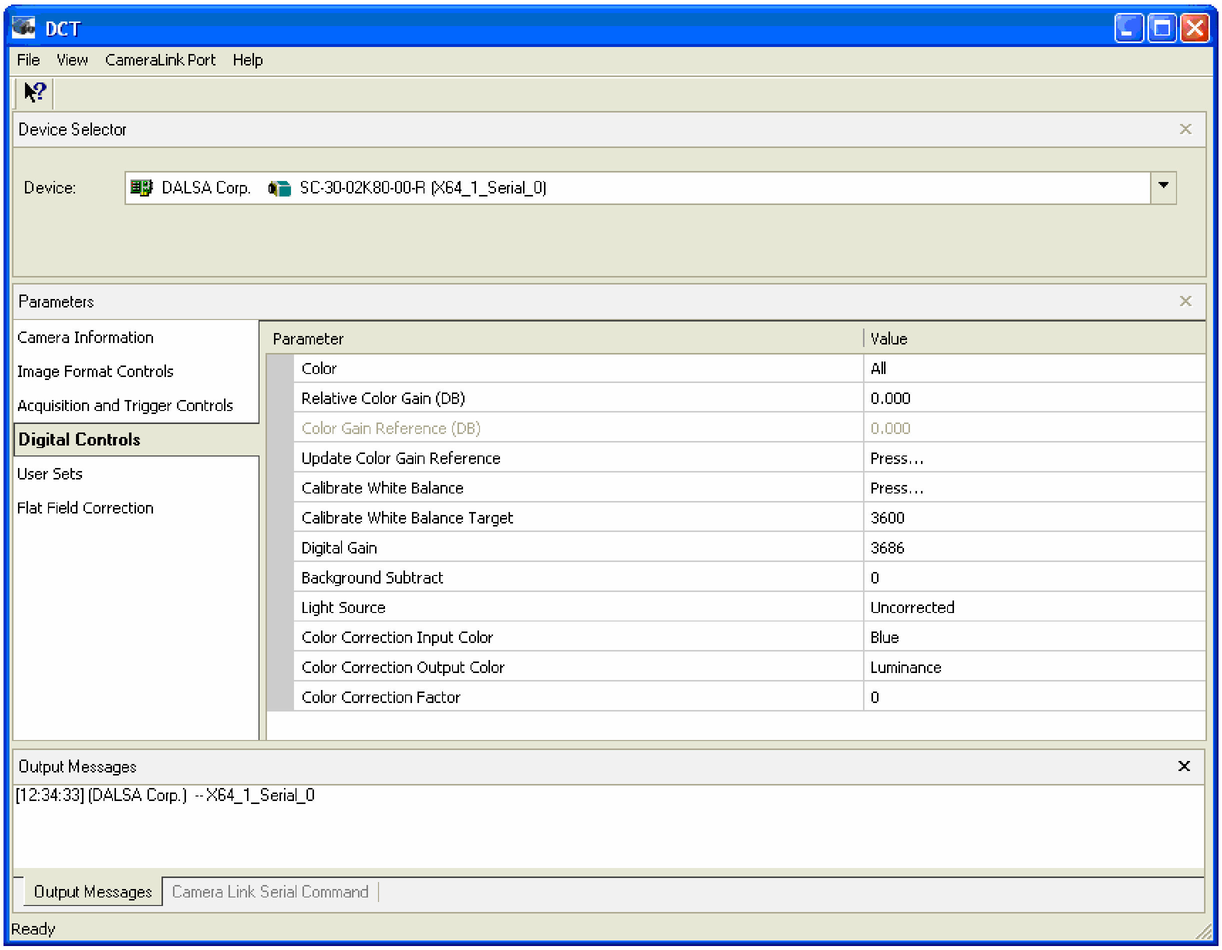
Figure 26: Acquisition and Trigger Controls



Name	Visibility	Description	ASCII Command	Command Range	Additional Information
Line Rate (Hz)	Expert	Line rate of the camera.	ssf	300 ~ 17900 Hz	Setting the Line Rate, page 35.
CCD Drection	Expert	CCD sensor direction.	scd	Internal Forward (0), Internal Reverse (1), External (2)	CCD Shift Direction, page 30.
Exposure Time	Guru	Exposure Time in microseconds. This feature is only configurable if Camera Internal Exposure mode is set to 2 and 6.	set	3 ~3300 (µs)	Setting the Exposure Time, page 35.
Internal Exposure Mode	Guru	Camera Internal Exposure Mode. This is set by the Trigger Mode and the Exposure Mode.	sem	NA	Setting the Exposure Mode, page 32.
Trigger Mode	Expert	The operation mode of the trigger for the acquisition.	slm	Internal, External	NA
Exposure Mode	Expert	The operation mode of the exposure control.	sec	Timed, Trigger Width,	NA

				Maximum Exposure Time	

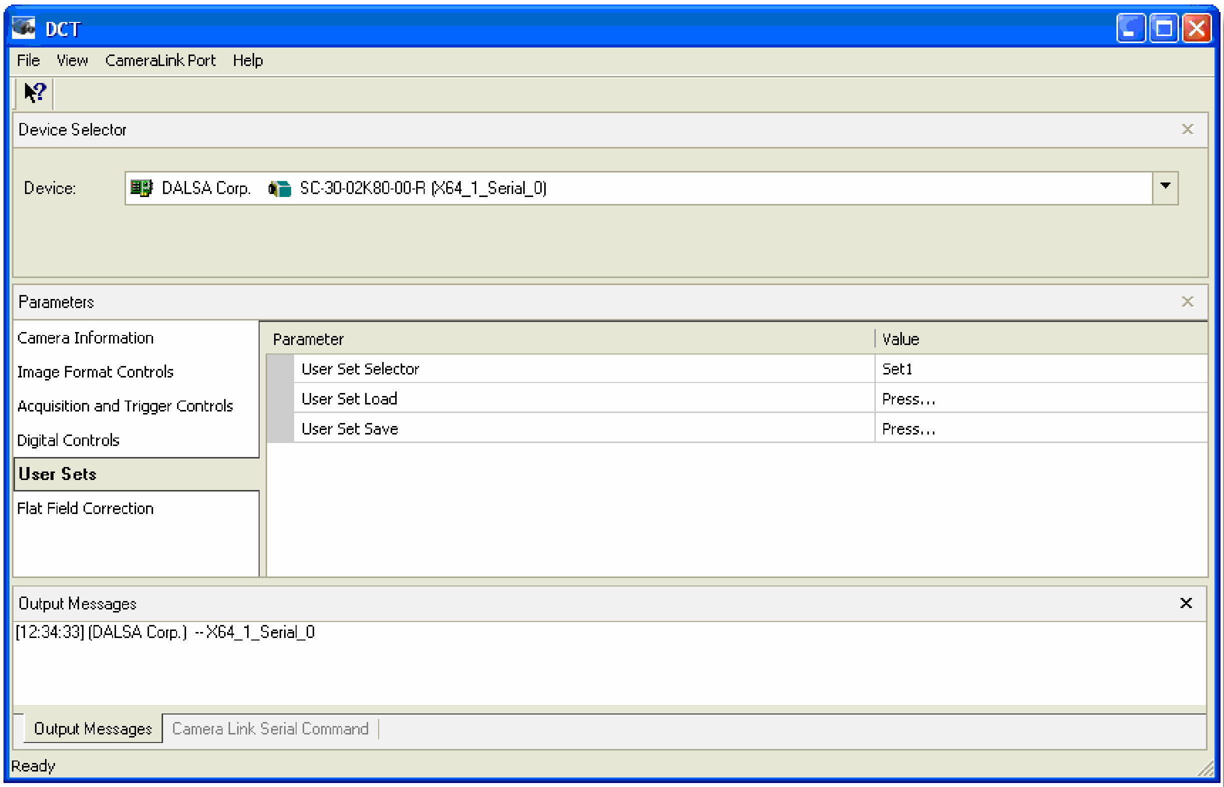
Figure 27: Digital Controls



Name	**Visibility**	**Description**	**ASCII Command**	**Command Range**	**Additional Information**
Color	Beginner	Selects the color to control. This feature has an affect on the color gains and color reference values.	scl	All, Red, Green, Blue	Setting Color Selector, page 39.
Color gain (DB)	Beginner	Color gain (DB) relative to color gain reference (DB) at the current tap and color setting.	scg	-20.00 ~ 20 DB	Setting Color Gain, page 39.
Color gain reference	Beginner	Color Gain Reference in DB at current tap and color setting.		NA	NA
Update Color Gain Reference	Beginner	Sets the current color gain value to 0.0 dB.	ucr	NA	NA
Digital Gain	Beginner	The digital gain in device units (DN).	ssg	0 ~ 65535 DN	Setting Digital System Gain, page

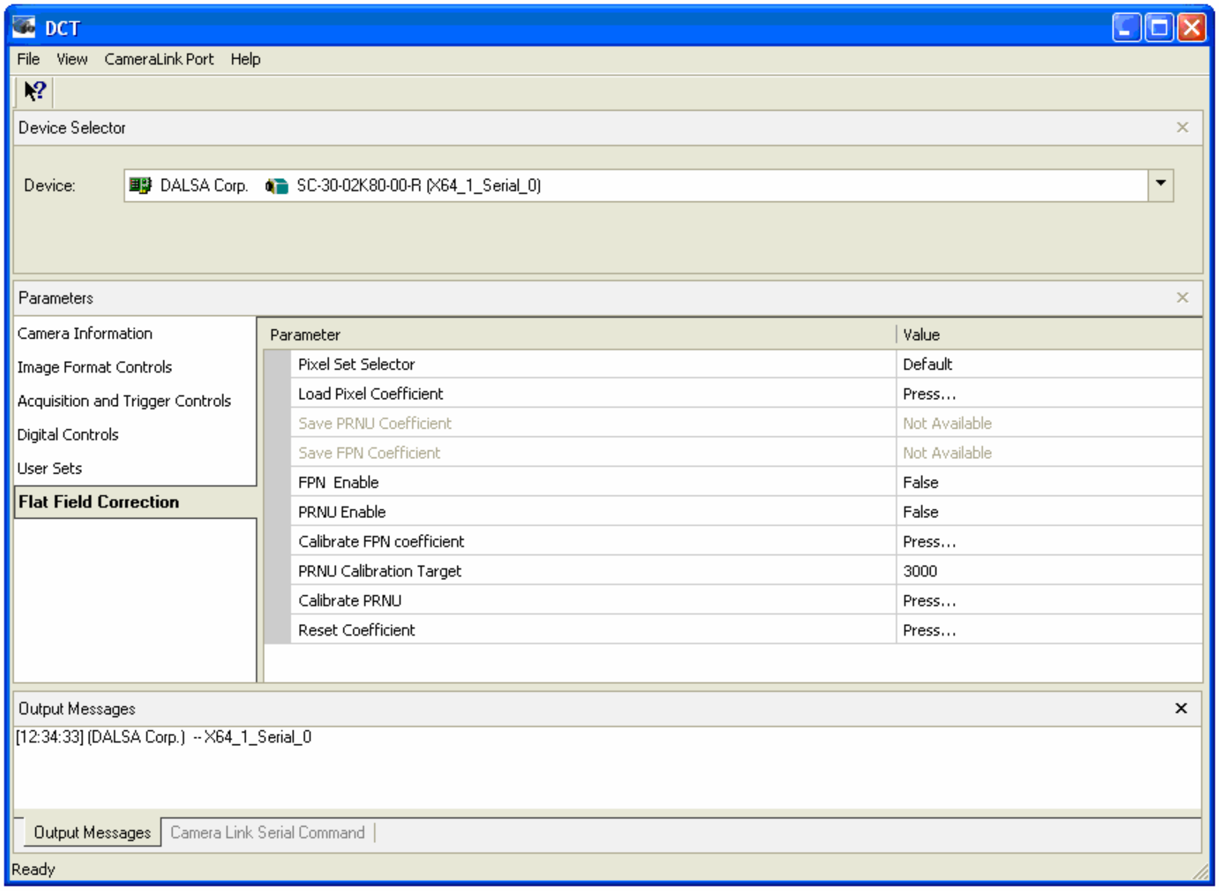
					48.
Background Subtract	Beginner	Subtracts a background value from digitized image data.	ssb	0 ~ 4095 DN	Subtracting Background, page 47.
Calibrate White Balance	Expert	Adjusts the color gains so that each color's average is equal to the target specified in Calibrate White Balance Target.	cwb	NA	Calibrate White Balance, page 39.
Calibrate White Balance Target	Expert	The target value for the Calibrate White Balance command.	cwb	1024~4055 DN	Calibrate White Balance, page 39.
Light Source	Beginner	Specify the adjustment to the color gain values for a given light source.	sls	Unadjusted (5200K) White LED. Halogen, Fluorescent, Tungsten	NA
Color Correction Input	Guru	Specifies the index for the color correction input value.	scx	Offset, Red, Green, Blue	Setting Color Correction X Index, page 40.
Color Correction Output	Guru	Specifies the color to correct using the color correction matrix.	scy	Red, Green Blue, Luminance	Setting Color Correction Y Index, page 40.
Color correction Factor	Guru	The color correction value for the given indices specified in Color Correction Input Color and Color Correction Output Color commands.	scc	-32000~32000	Setting Color Correction, page 39.

Figure 28: User Sets



Name	Visibility	Description	Camera Command	Command Range	Additional Information
User Set Selector	Beginner	This feature selects which User Set to load, save or configure. The default is reserved for factory user to save factory calibrated data, and can only be read. If the user wants to save another setting, they need to set the user selector to a value other than default.	sus	Default, set1, set2, set3, set4, set5, set6, set7, set8	Saving and Restoring Settings, page 51.
User Set Load	Beginner	Loads the User Set specified by User Set Selector to the device, and makes it active.	rus	NA	Saving and Restoring Settings, page 51.
User Set Save	Expert	Save the User Set specified by User Set Selector to the non-volatile memory of the device.	wus	NA	Saving and Restoring Settings, page 51.

Figure 29: Flat Field Correction



Name	Visibility	Description	ASCII Command	Command Range	Additional Information
Pixel Set Selector	Beginner	This feature selects which pixel set to load and save. The default is reserved for factory user to save factory calibrated data, and can only be read. If they want to save another set of coefficients, they need to set Pixel Set Selector to a value other than the default.	sfs	Default, set1, set2, set3, set4, set5, set6, set7, set8	Saving and Restoring PRNU and FPN Coefficients, page 52.
Load Pixel Coefficient	Beginner	Loads the Flat Field Correction Coefficients (specified by the Pixel Set Selector) from the cameras non-volatile memory.	lpc	NA	Saving and Restoring PRNU and FPN Coefficients, page 52.
Save PRNU Coefficient	Expert	Saves the PRNU Correction Coefficients (specified by the Pixel Set Selector) to the camera's non-volatile memory.	wpc	NA	Saving and Restoring PRNU and FPN Coefficients, page 52.
Save FPN	Expert	Saves the FPN Correction	wfc	NA	Saving and

Coefficient		Coefficients (specified by the Pixel Set Selector) to the camera's non-volatile memory.			Restoring PRNU and FPN Coefficients, page 52.
Calibrate FPN	Guru	Calibrate FPN. Ensure that you cover the sensor completely.	ccf	NA	FPN Correction, page 46.
Calibrate PRNU	Guru	Calibrate PRNU coefficient. Ensure proper light, and target specified in the PRNU calibration target.	cpa	NA	PRNU Correction, page 47.
PRNU Calibration Target	Guru	PRNU calibration target	cpa	1024 ~ 4055	PRNU Correction, page 47.
FPN Enable	Beginner	The state of the FPN Correction.	efc	False, True	Enable FPN Coefficients, page 49.
PRNU Enable	Beginner	The state of the PRNU Correction.	epc	False, True	Enable PRNU Coefficients, page 49.
Reset Coefficient	Guru	Reset Pixel FPN and PRNU coefficients to zero.	rpc	NA	Resetting the Current Pixel Coefficients, page 52.

6 Appendix A

6.1 Camera Link™ Reference, Timing, and Configuration Table

Camera Link is a communication interface for vision applications. It provides a connectivity standard between cameras and frame grabbers. A standard cable connection will reduce manufacturers' support time and greatly reduce the level of complexity and time needed for customers to successfully integrate high speed cameras with frame grabbers. This is particularly relevant as signal and data transmissions increase both in complexity and throughput. A standard cable/connector assembly will also enable customers to take advantage of volume pricing, thus reducing costs.

The camera link standard is intended to be extremely flexible in order to meet the needs of different camera and frame grabber manufacturers.

The DALSA Camera Link Implementation Road Map (available at from http://mv.dalsa.com) details how DALSA standardizes its use of the Camera Link interface.

LVDS Technical Description

Low Voltage Differential Signaling (LVDS) is a high speed, low power, general purpose interface standard. The standard, known as ANSI/TIA/EIA-644, was approved in March 1996. LVDS uses differential signaling, with a nominal signal swing of 350mV differential. The low signal swing decreases rise and fall times to achieve a theoretical maximum transmission rate of 1.923 Gbps into a loss-less medium. The low signal swing also means that the standard is not dependent on a particular supply voltage. LVDS uses current-mode drivers, which limit power consumption. The differential signals are immune to ±1 V common volt noise.

Camera Signal Requirements

This section provides definitions for the signals used in the Camera Link interface. The standard Camera Link cable provides camera control signals, serial communication, and video data.

Video Data

The Channel Link technology is integral to the transmission of video data. Image data and image enable signals are transmitted on the Channel Link bus. Four enable signals are defined as:

• FVAL—Frame Valid (FVAL) is defined HIGH for valid lines.

• LVAL—Line Valid (LVAL) is defined HIGH for valid pixels.

• DVAL—Data Valid (DVAL) is defined HIGH when data is valid.

• Spare— A spare has been defined for future use.

All four enable signals must be provided by the camera on each Channel Link chip. All unused data bits must be tied to a known value by the camera. For more information on image data bit allocations, refer to the official Camera Link specification located at http://mv.dalsa.com.

Camera Control Signals

Four LVDS pairs are reserved for general purpose camera control. They are defined as camera inputs and frame grabber outputs. Camera manufacturers can define these signals to meet their needs for a particular product. The signals are:

• Camera Control 1 (CC1)

• Camera Control 2 (CC2)

• Camera Control 3 (CC3)

The camera uses the following control signals:

Table 19: DALSA Camera Control Configuration

CC1	EXSYNC, negative edge active
CC2	PRIN
CC3	Direction

Communication

Two LVDS pairs have been allocated for asynchronous serial communication to and from the camera and frame grabber. Cameras and frame grabbers should support at least 9600 baud. These signals are

• SerTFG—Differential pair with serial communications to the frame grabber.

• SerTC—Differential pair with serial communications to the camera.

The serial interface will have the following characteristics: one start bit, one stop bit, no parity, and no handshaking. It is recommended that frame grabber manufacturers supply both a user interface and a software application programming interface (API) for using the asynchronous serial communication port. The user interface will consist of a terminal program with minimal capabilities of sending and receiving a character string and sending a file of bytes. The software API will provide functions to enumerate boards and send or receive a character string.

Power

Power will not be provided on the Camera Link connector. The camera will receive power through a separate cable. Camera manufacturers will define their own power connector, current, and voltage requirements.

6.2 Camera Link Bit Definitions

BASE Configuration Mode	T0			T1 (Note: Entries imply double frequency pixel rate data transmission)		
Mode	PORT A Bits 0 thru 7	PORT B Bits 0 thru 7	PORT C Bits 0 thru 7	PORT A Bits 0 thru 7	PORT B Bits 0 thru 7	PORT C Bits 0 thru 7
Mode 0, 1	G	G				
1 Tap n bit Where Mode 0 = 8 bit Mode 1 = 12 bit	LSB….Bit 7	Bit 8….MSB xxxx	xxxxxxx x= don't care for unused bits	N/A	N/A	N/A
Mode 2						
2 Tap 8 bit	RBRBRB… LSB..Bit 7	GGGGGG… LSB..Bit 7	xxxxxxx	N/A	N/A	N/A
Mode 3						
2 Tap n bit Where n= 12	RBRB… LSB.. Bit 7	RBRB… Bits 8,9,10,11, G Bits 8,9,10,11	G LSB..Bit 7	N/A	N/A	N/A
Mode 5						
RGB 8 bit	R LSB…Bit 7	G LSB…Bit 7	B LSB…Bit 7	N/A	N/A	N/A
Mode 6						
RGB 12 bit	R LSB.. Bit 7	R Bits 8,9,10,11, B Bits 8,9,10,11	B LSB…Bit 7	G LSB… Bit 7	G Bits 8,9,10,11 xxxx	xxxxxxxx
Mode 9						
Color RGBY 8 bit	R LSB..Bit 7	B LSB..Bit 7	xxxxxxxx	G LSB..Bit 7	Y LSB..Bit 7	xxxxxxxx
Mode 10						
Color RGBY 12 bit	R LSB..Bit 7	R Bits 8, 9,10, 11 B Bits 8, 9,10, 11	B LSB..Bit 7	G LSB…Bit 7	G Bits 8, 9,10, 11 Y Bits 8, 9,10, 11	Y LSB..Bit 7

6.3 Camera Link Configuration Tables

The following table provides tap reconstruction information. DALSA is working with the machine vision industry to use this table as the basis for auto configuration. Visit the http://mv.dalsa.com Web site and view the DALSA Camera Link Implementation Road Map document, 03-32-00450, for further details.

SC-30-0xk80 Interface Parameters

Note: PRELIMINARY

Table 20: Framegrabber Interface Parameters

Item (when programmable configuration the options are separated with a |)	SC-30-02k80	SC-30-04k80
Imager Dimension <1,2 or 1|2>	1	1
Imager Columns<number of active columns, X>	2048	4096
Imager Rows<number of active rows, Y> Line Scan/TDI are defined as 1	1	1
Number of CCD Taps <1,2,3…..>	2	2
Sensor Tap Clock Rate <xx MHz>	40	40
Camera Standard <NTSC, PAL, VS, VW, MW>	VS	VS
Variable Window <Column Start, Column End, Row Start, Row End>	(0,0,0,0) All zeros indicates an unsupported feature	(0,0,0,0) All zeros indicates an unsupported feature
Multiple Window Number of Windows (Column Start 1, Column End 1, Row Start 1, Row End 1) (Column Start 2, Column End 2,...)	0, (0,0,0,0) All zeros indicates an unsupported feature	0, (0,0,0,0) All zeros indicates an unsupported feature
Number of Camera Configurations<1,2,3,…>	2	2
Configuration Definition Cx= HDW, Number of Output Taps, Bit Width, Number of Processing Nodes where Cx is the configuration ID x is <1,2,3…> HDW is <Base, Medium, Full> Number of Output Taps is <1,2,3…> Bit width is <8, 10, 12…> Number Processing Nodes is <1 or 2>	C1 = Base, 2, 8, 1 C2 = Base, 2, 12, 1	C1 = Base, 2, 8, 1 C2 = Base, 2, 12, 1

Item (when programmable configuration the options are separated with a |)	SC-30-02k80	SC-30-04k80
Tap Reconstruction In some configurations the reconstruction may change. C0 is the default output format and must be listed. Output configurations that don't conform are listed separately. <Cx,Tn (Column Start, Column End, Column Increment, Row Start, Row End, Row Increment>	Horizontal mirroring is supported. Mirror "on" changes the following unmirrored values to: • The sign of the column increment is inverted. • Column Start becomes the Column End value • Column End becomes the Column Start value Direction left to right readout C0, T1 (1, 1024, 1, 1, 1, 1) C0, T2 (1025, 2048, 1, 1, 1, 1)	Horizontal mirroring is supported. Mirror "on" changes the following unmirrored values to: • The sign of the column increment is inverted. • Column Start becomes the Column End value • Column End becomes the Column Start value Direction left to right readout C0, T1 (1, 2048, 1, 1, 1, 1) C0, T2 (2049, 4096, 1, 1, 1, 1)
Camera Color <Hybrid, Mono, Pattern, Solid>	Mono	Mono
RGB Pattern Size < (T1, Columns*Rows) (T2, Columns*Rows) (T3, Columns*Rows….>	(T0, 1*1) where 0 is reserved for the default case and individual taps don't need to be articulated	(T0, 1*1) where 0 is reserved for the default case and individual taps don't need to be articulated
Color Definition (Column, Row, Color) Where color is R,G,B	T0 = (1, 1, M) where 0 is reserved for the default case and individual taps don't need to be defined	T0 = (1, 1, M) where 0 is reserved for the default case and individual taps don't need to be defined
Row Color Offset <0,1,2,3…>	0	0
Column Color Offset <0,1,2,3…>	0	0
Row Binning Factor <1,2,3 or 1|2|3>	1	1
Column Binning Factor <1,2,3 or 1|2|3>	1| 2	1| 2
Pretrigger Pixels <0,1,2…or 0..15>	0	0
Pretrigger Lines <0,1,2.. or 0..15>	0	0
Frame Time Minimum <xx μs>	27.78	54.05
Frame Time Maximum <xx μs>	3333	3333

Item (when programmable configuration the options are separated with a |)	SC-30-02k80	SC-30-04k80
Internal Line/Frame Time Resolution <xx ns> 0 if not applicable	25	25
Pixel Reset Pulse Minimum Width <xx ns> 0 if not applicable	3000	3000
Internal Pixel Reset Time Resolution <xx ns> 0 if not applicable	25	25
Pixel Reset to Exsync Hold time <xx ns>		
BAUD Rate <9600….>	9600, 19200, 57600, 115200	9600, 19200, 57600, 115200
CC1 <Exsync>	EXSYNC	EXSYNC
CC2 <PRIN>	PRIN	PRIN
CC3 <Forward, Reverse>	Forward/ Reverse	Forward/ Reverse
CC4 <Spare>	Spare	Spare
DVAL out <Strobe Valid, Alternate>	Strobe Valid	Strobe Valid
Spare out <Spare> (For future use)	Spare	Spare

7 Appendix B

7.1 Declaration of Conformity

MIL-STD-810E

Others pending.

8 Appendix C

8.1 Troubleshooting

The information in this chapter can help you solve problems that may occur during the setup of your camera. Remember that the camera is part of the entire acquisition system. You may have to troubleshoot any or all of the following:

- power supplies
- software
- light sources
- operating environment
- cabling
- host computer
- optics
- encoder

LED

When the camera is first powered up, the LED will glow on the back of the camera. Refer to section 2.4 for information on the LED.

Connections

The first step in troubleshooting is to verify that your camera has all the correct connections.

See the section detailing the camera connections, section 2.2 Input/Output Connectors and LED, page 11.

Equipment Requirements

Ensure that you are using compatible equipment.

Power Supply Voltages

Check for the presence of all voltages at the camera power connector. Verify that all grounds are connected. Verify input voltage with the camera's 'vv' serial command.

EXSYNC

When the camera is received from the factory, it defaults (no external input required) to exposure mode 7 (1600 Hz line rate, internal Sync to trigger readout). After a user has saved settings, the camera powers up with the saved settings.

If you change to an exposure mode that requires an external sync, ensure that you properly providing an external sync

Camera Operation and Test Patterns

Have the camera send out a test pattern and verify it is being properly received.

Communications

To quickly verify serial communications send the help command. The **`h`** command returns the online help menu. If further problems persist, review Appendix C for more information on communications.

Verify Parameters

To verify the camera parameters, send the **`gcp`** command. A complete explanation of the camera parameters screen follows.

Verify Timing and Digital Video Path

Use the test pattern feature to verify the proper timing and connections between the camera and the frame grabber and verify the proper output along the digital processing chain. See below.

Generating Test Patterns

The camera can generate a test pattern to aid in system debugging. Use the command **`svm 1`** to activate the test pattern. The test pattern is a ramp from 0 to 255DN, then starts at 0 again. Use the test pattern to verify the proper timing and connections between the camera and the frame grabber.

- **No test pattern or bad test pattern**— May indicate a problem with the camera (e.g. missing bit) or a system setup problem (e.g. frame grabber or timing). Verify the presence of the LVAL and STROBE signals.
- **Test pattern successful**— Run the **`svm 0`** command to activate video. Then run the **`gl`** command under both dark and light conditions to retrieve a line of raw video (no digital processing). Under dark conditions, with factory settings, the analog offset value should be within the specified range (refer to the user specifications).

Verify Voltage

Use the **`vv`** command to display the camera's input voltage.

Verify Temperature

To check the internal temperature of the camera, use the **vt** command. For proper operation, this value should not exceed 75°C.

Note: If the camera reaches 75°C, the camera **will shutdown and the LED will flash red**. If this occurs, the camera **must be rebooted** using the command, **rc** or can be powered down manually. You will have to correct the temperature problem or the camera will shutdown again. If you enter any command other than **vt** or **rc**, the camera responds with:

Error 09: The camera's temperature exceeds the specified operating range>

Verify Pixel Coefficients

Use the **dpc** command to display the pixel coefficients in the order FPN, PRNU, FPN, PRNU… The camera also returns the pixel number for each fifth pixel.

End-of-line Sequence

To further aid debugging, the camera can generate an end-of-line sequence. The end-of-line-sequence outputs "aa", "55", "line counter", "line average", "pixels above threshold", "pixels below threshold". To activate the end-of-line sequence, use the commands **els 3 (LVAL extended by 16 (stat) pixels) or els 7 (LVAL shifted by 16 pixels to encompass stat pixels)**. To disable the end-of-line sequence, use the command **els 0**.

Use the **sut** and **slt** commands to set threshold values between 0 and 255 for 8 bit data modes, or 0 to 4096 for 12 bit data modes.

8.2 Specific Solutions

No Output or Erratic Behavior

If your camera provides no output or behaves erratically, it may be picking up random noise from long cables acting as antennae. Do not attach wires to unused pins. Verify that the camera is not receiving spurious inputs (e.g. EXSYNC if camera is in exposure mode that requires external signals).

Line Dropout, Bright Lines, or Incorrect Line Rate

Verify that the frequency of the internal sync is set correctly, or when the camera is set to external sync that the EXSYNC signal supplied to the camera does not exceed the camera's useable Line rate under the current operating conditions.

Noisy Output

Check your power supply voltage outputs for noise. Noise present on these lines can result in poor video quality.

Dark Patches

If dark patches appear in your output the optics path may have become contaminated. Clean your lenses and sensor windows with extreme care.

1. Take standard ESD precautions.
2. Wear latex gloves or finger cots
3. Blow off dust using a filtered blow bottle or dry, filtered compressed air.
4. Fold a piece of optical lens cleaning tissue (approx. 3" x 5") to make a square pad that
5. is approximately one finger-width
6. Moisten the pad on one edge with 2-3 drops of clean solvent—either alcohol or acetone. Do not saturate the entire pad with solvent.
7. Wipe across the length of the window in one direction with the moistened end first, followed by the rest of the pad. The dry part of the pad should follow the moistened end. The goal is to prevent solvent from evaporating from the window surface, as this will end up leaving residue and streaking behind.
8. Repeat steps 2-4 using a clean tissue until the entire window has been cleaned.
9. Blow off any adhering fibers or particles using dry, filtered compressed air.

Horizontal Lines or Patterns in Image

A faulty or irregular encoder signal may result in horizontal lines due to exposure time fluctuations; ensure that your exposure time is regular. If you have verified that your exposure time is consistent and patterns of low frequency intensity variations still occur, ensure that you are using a DC or high frequency light source.

8.3 Product Support

If there is a problem with your camera, collect the following data about your application and situation and call your DALSA representative.

Note: You may also want to photocopy this page to fax to DALSA.

Customer name	
Organization name	
Customer phone number **fax number** **email**	
Complete Product Model Number **(e.g. SC-30-02k80-00-R)**	
Complete Serial Number	
Your DALSA Agent or Dealer	
Acquisition System hardware (frame grabber, host computer, light sources, etc.)	
Power supply setting and current draw	
Pixel rate used	
Control signals used in your application, and their frequency or state (if applicable)	EXSYNC BIN LVDS/TTL Other _______
Results when you run an error report	*please attach text received from the camera after initiating an error report*
Detailed description of problem encountered.	*please attach description with as much detail as appropriate*

In addition to your local DALSA representative, you may need to call DALSA Technical Sales Support:

DALSA Sales Offices

North America	Europe	Asia Pacific
700 Technology Park Drive Billerica, MA USA, 01821 Tel: 978-670-2000 Fax: 978-670-2010 sales.americas@dalsa.com	Breslauer Str. 34 D-82194 Gröbenzell (Munich) Germany Tel: +49 - 8142 – 46770 Fax: +49 - 8142 – 467746 sales.europe@dalsa.com	Ikebukuro East 1 3F 3-4-3 Higashi Ikebukuro Toshima-ku, Tokyo Japan +81 3 5960 6353 (phone) +81 3 5960 6354 (fax) sales.asia@dalsa.com

9 Appendix D

9.1 Electrostatic Discharge and the CCD Sensor

Cameras contain charge-coupled device (CCD) image sensors, which are metal oxide semiconductor (MOS) devices and are susceptible to damage from electrostatic discharge (ESD).

Electrostatic charge introduced to the sensor window surface can induce charge buildup on the underside of the window that cannot be readily dissipated by the dry nitrogen gas in the sensor package cavity. When charge buildup occurs, surface-gated photodiodes (SGPDs) may exhibit higher image lag. Some SGPD sensors, such as the IL-P4 and the IT-P4 used in the DALSA's cameras, may also exhibit a highly non-uniform response when affected by charge buildup, with some pixels displaying a much higher response when the sensor is exposed to uniform illumination. The charge normally dissipates within 24 hours and the sensor returns to normal operation.

WARNING: Charge buildup will affect the camera's flat-field correction calibration. To avoid an erroneous calibration, ensure that you perform flat-field correction only after a charge buildup has dissipated over 24 hours.

9.2 Protecting Against Dust, Oil and Scratches

The CCD window is part of the optical path and should be handled like other optical components, with extreme care.

Dust can obscure pixels, producing dark patches on the sensor response. Dust is most visible when the illumination is collimated. The dark patches shift position as the angle of illumination changes. Dust is normally not visible when the sensor is positioned at the exit port of an integrating sphere, where the illumination is diffuse.

Dust can normally be removed by blowing the window surface using a compressed air blower, unless the dust particles are being held by an electrostatic charge, in which case either an ionized air blower or wet cleaning is necessary.

Oil is usually introduced during handling. Touching the surface of the window barehanded will leave oily residues. Using rubber fingercots and rubber gloves can prevent oil contamination. However, the friction between the rubber and the window may produce electrostatic charge that may damage the sensor. To avoid ESD damage and to avoid introducing oily residues, only hold the sensor from the edges of the ceramic package and avoid touching the sensor pins and the window.

Scratches can be caused by improper handling, cleaning or storage of the sensor. Vacuum picking tools should not come in contact with the window surface. CCDs should not be stored in containers where they are not properly secured and can slide against the container.

Scratches diffract incident illumination. When exposed to uniform illumination, a sensor with a scratched window will normally have brighter pixels adjacent to darker pixels. The location of these pixels changes with the angle of illumination.

4.3 Cleaning the Sensor Window

1. Use compressed air to blow off loose particles. This step alone is usually sufficient to clean the sensor window.
2. If further cleaning is required, use a lens wiper moistened with alcohol or acetone.
3. We recommend using lint-free ESD-safe cloth wipers that do not contain particles that can scratch the window. The Anticon Gold 9”x 9” wiper made by Milliken is both ESD safe and suitable for class 100 environments. Another ESD acceptable wiper is the TX4025 from Texwipe.
4. An alternative to ESD-safe cloth wipers is Transplex swabs that have desirable ESD properties. There are several varieties available from Texwipe. Do not use regular cotton swabs, since these can introduce charge to the window surface.
5. Wipe the window carefully and slowly.
6. When cleaning long linear sensors, it may be easier to wipe along the width (i.e. as opposed to the length) of the sensor.

10 Appendix E

10.1 Revision History

Revision Number	Change Description	Date
00	Preliminary release.	June 26, 2009

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